



Final Report
**Comprehensive Roadway
Illumination Study • Phase IV**

C I T Y O F T U C S O N

January, 2003

*TRANS***CORE**

COMPREHENSIVE ROADWAY ILLUMINATION STUDY

PHASE IV Final Report

*Prepared for
City of Tucson*

Prepared by
TRANS CORE



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EXECUTIVE SUMMARY

PROJECT PERSPECTIVES

The Comprehensive Roadway Illumination Project was originally conceived by the City of Tucson in 1978. The need for a detailed analysis of roadway lighting policies, safety effects, and funding became apparent as traffic volumes and nighttime safety problems increased during the 1970s. The city Department of Transportation retained the firm of TransCore (then JHK & Associates) to provide consultant engineering services for the project. This current project represents the fourth phase of the city's continuing evaluation of lighting systems on arterial and collector roadways.

The general objectives of the project in its previous and current phases was to review and analyze arterial and major collector streets in the City of Tucson to determine which would benefit most from an improved nighttime visual environment for drivers, pedestrians, and bicyclists.

The elements which were completed during the project are described below.

- **Inventory and Evaluation of Existing Systems.** Field measurements of actual on-street lighting levels were taken and an inventory of existing systems was made.
- **Safety Analysis.** A detailed review and analysis of 3 years of accident data was made for 142 arterial streets segments.
- **Warrant Rating System.** Application of a system of warrants for street lighting installation was another project activity. A comprehensive evaluation procedure was applied in order to prioritize roadway lighting needs with the City of Tucson.
- **Comprehensive Roadway Illumination Program.** A recommended 10-year lighting program was developed, with a total capital cost estimate of \$36.7 million.

HISTORICAL BACKGROUND

Tucson has a long history of roadway lighting projects. The earliest systems, utilizing incandescent bulbs, were installed in the early 1900s in and near the downtown area.

In the 1930s and 1940s more incandescent systems were installed and during the 1950s and 1960s new systems based on mercury vapor lamps were installed along Miracle Mile, Speedway Boulevard, Broadway Boulevard, and several other arterial roadways. The city installed only a few new systems in the 1970s, and these were based on the more efficient high-

pressure sodium lamps. Since 1979, the City of Tucson has almost completed a total conversion to high pressure sodium lighting systems.

NIGHT ACCIDENT EXPERIENCE

The detailed analysis of three years (1999 through 2001) of accident data was applied to 127 miles of arterial streets, divided into 142 numbered “segments” for computational purposes. Six accident measures were computed; night frequency, night rate, rate ratio (night/day), frequency ratio (night/day), total frequency, and total rate. The warrant analysis included the ratio of night/day accident rates as an element in prioritizing projects.

SUMMARY OF PROJECT FINDINGS

The recommended 10-year program is comprised of the following principal elements:

- **New Arterial Systems.** Ninety-five projects comprising 84 miles and costing a total of \$36.7 million.
- **Modifying Luminaire Mounting Height for New Lighting Systems from 35 feet to 40 feet.** An evaluation of luminaire mounting height on new lighting systems resulted in recommending a 40-foot mounting height, instead of the current practice of 35-foot mounting height in order to enhance nighttime lighting levels.

The major benefit accruing to the city following program implementation will be a safer nighttime environment for drivers, pedestrians, and bicyclist on major streets.

The predominant element in the program involves the implementation of new lighting systems along arterial segments. This construction element entails a relatively large commitment of funds and a substantial level of effort in each year of the program.

1. INTRODUCTION

PREVIOUS STUDIES

The need for a comprehensive program to address roadway lighting in the City of Tucson was identified in 1978. The components of this program included a detailed analysis of roadway lighting policies, public safety, energy utilization, maintenance, astronomy impacts and funding. The City of Tucson contracted with TransCore (formerly JHK & Associates) initially in 1979 (Phase I), in 1983 (Phase II), and in 1992 (Phase III), for the major goal of developing a cost-effective capital improvement program for the installation of arterial street and intersection lighting systems within the city.

These projects also contributed to the development of several key technical areas, providing recommendations on the issue of high pressure sodium luminaires, the placement of light poles adjacent to the roadway, and the establishment of acceptable lighting level standards for both arterials and intersections. The following points summarize the key work tasks and recommendations presented in Phases I, II, and III of the Comprehensive Roadway Illumination Study.

Phase I Study

1. Definition of Project Objectives – The initial study's first major task was to identify and define the major project objectives. To a large extent, these objectives have been carried through for each of the successive studies. They include:
 - Inventory and Evaluation of Existing Systems – Field investigations to document and evaluate existing system configurations and performance.
 - Safety Analysis – Detailed review and analysis of several years of accident data in order to identify high accident locations, based on a number of criteria.
 - Warrant Rating System – The first study developed and implemented a method of evaluating roadway segments and intersections in order to identify and rank projects to be included in a capital improvement program. This procedure has been used for each of the studies in the program.
 - System Performance Objectives – A set of specific objectives were established for roadway illumination in Tucson. These objectives included environmental, safety, astronomical, cost, and energy use factors. These objectives continue to be followed by the city.

- Comprehensive Roadway Illumination Program – The first five-year capital improvement program for the period of 1979 to 1984 was recommended as a result of this study. Phase II continued the process with the recommendation of the 1984 to 1989 improvement program. In 1992, the Phase III study expanded the capital improvement program to a ten-year program.
2. Development of Street Lighting Objectives – A review of then current technology and Tucson lighting practices yielded guidelines in three major areas, including (1) preferred lighting technology (high pressure sodium), (2) prime performance parameters (relatively low illumination levels with relatively high uniformity ratios), and (3) efficient mounting configurations (relatively high mounting heights).
 3. Development of an Analytical Method of Determining project Priorities – This is a two-part procedure of identifying roadway segments and intersections where lighting improvements were “warranted,” and then developing a prioritized list of segments based on cost-effectiveness. This procedure was developed in Phase I, and continues to serve as an effective decision-making tool. The procedure is explained in more detail in Chapter 4.

Phase II Study

1. Review of Street Light Pole Placement Standards – The major task of the study Phase II (in addition to development of the five-year program) was to review the accident history of the existing lighting system relative to pole location, and provide recommendations for future projects in order to enhance traffic safety. The following statements summarize the recommendations of Phase II.
 - Street luminaires placed along the outside lane of a street should normally have a two-foot lateral clearance from the edge of the pole as conditions allow.
 - Placement of street luminaires on the property side of the sidewalk if recommended. If no sidewalk exists, the poles may be in the area behind a future sidewalk, generally five feet from the edge of the travel lane to the street face(s) of the pole.
 - Street lights placed in a median island should have a four-foot clearance from the edge of the travel lane to the street face(s) of the pole.
 - Median luminaires at signalized intersections should be combined with signal/luminaire on the right side of the road. Signal indications may remain on the median islands.
 - Breakaway luminaire poles are not generally recommended for the City of Tucson’s arterials. Parkways may be suitable for consideration of breakaway poles.
 - In no case shall these breakaway devices be used in conjunction with traffic signal poles or combination traffic signal/lighting poles.
 - Concrete pedestal foundations should be removed and converted to flush mount concrete foundations.

Phase III Study

The Phase III Study expanded the Capital Improvement Program for Lighting Projects to a ten-year program. Phase II also included several additional studies at the city's request. These studies included:

- Use of low-pressure sodium lighting in residential areas
- A review of existing policies relating to street light pole configurations
- Application of Illuminating Engineering Society (IES) illuminance or luminance criteria
- The development of a single-phase and three-phase wire sizing program
- A review of tunnel and underpass lighting
- The cost-effectiveness and feasibility of using three-phase electrical sources
- Concrete pedestal foundations should be removed and converted to flush mount concrete foundations.

PROJECT OBJECTIVES

The objectives of the fourth phase of the Comprehensive Roadway Illumination Study were twofold. First, development of the next ten-year roadway lighting capital improvement program was the overall main objective. In order to accomplish this, an accident analysis, and a warranting and prioritization analysis were performed. Chapters 3, 4, and 5 of this document described the methodology and results of these analyses. Second, city staff requested an analysis of pole heights for luminaires to be performed to answer current issues relative to city lighting practices.

PRODUCTS

The major products of this study include the following items:

1. Recommended Ten-Year Roadway Lighting Capital Improvement Program.
2. Project report documenting the study methodology and results, and summarizing recommendations on each of the specific design issues.

2. EXISTING LIGHTING SYSTEMS

As a continuation of the inventory efforts conducted during Phases I, II, and III of this study, TransCore performed an update to the inventory of existing street lighting systems in the City of Tucson. This included a review of as-built construction plans and selected field investigations to verify pole configurations and setbacks. System characteristics including installation date, segment length, luminaire type and wattage, spacing, setback, and pole placement configuration are provided where available. Exhibit 1 provides a summary of the 196 segments inventoried. Exhibit 2 is a map depicting the existing lighting systems.

Segments in Exhibit 2 are identified as being installed before the year 1983 or installed after the year 1983. Some segments are also identified as being “pre-1983” or “post-1983” in Exhibit 1 where the actual date of implementation was not found in existing as-builts, but was estimated by the City of Tucson’s project manager. Roadway lighting systems have a theoretical service life of approximately twenty years (although the luminaires themselves are replaced more frequently). Several roadway lighting systems identified as being implemented prior to 1983 (twenty years before this document is published) were selected for an analysis of existing lighting levels and lighting uniformity. This analysis is described in Chapter 6 of this report.

As shown in Exhibit 1, most of the systems utilize 400-watt luminaires, and poles are configured in a staggered pattern on both sides of the road. Pole setbacks vary depending on the roadway segment, however, all segments conform to a minimum two-foot setback recommended in the Phase II Illumination Study. Roadway lighting installed as part of roadway improvement projects is typically configured with the poles behind the sidewalk, at a setback of approximately nine feet. This is a desirable configuration when sufficient right-of-way is available as it helps remove the pole as an obstruction for errant vehicles.

Exhibit 1

EXISTING OR IN-DESIGN STREET LIGHTING SYSTEMS

No.	Street Name	From Street	To Street	Date Built	(Miles)	Length Wattage & Type (Feet)	Average Spacing (Feet)	Typical Setback (Feet)	Pole Placement	City Project No.
1	12th Avenue	44th Street	Ajo Way	Oct-73	0.7	250 HPS	142	2.0	Staggered	F-71-04
2	12th Avenue	Ajo Way	Drexel Road	Aug-80	1.9	250 HPS	220	2.0	Staggered	F-73-02
3	12th Avenue	Drexel Road	Valencia Road	2000	1.0	400 HPS	110	10.0	Staggered	I-96-61
4	1st Avenue	Prince Road	Grant Road	Oct-88	1.5	400 HPS	160	6.5	Staggered	F-85-18
5	22nd Street	Mission Road	I-10	May-86	0.8	400 HPS	170	Varies	Staggered	I-84-08
6	22nd Street	Kino Parkway	Tucson Blvd	Apr-87	0.8	400 HPS	104	Varies	Staggered	F-85-16
7	22nd Street	Tucson Blvd	Alvernon Way	Nov-86	1.5	400 HPS	100	Varies	Staggered	F-85-10
8	22nd Street	Alvernon Way	Craycroft Road	Oct-93	2.0	400 HPS	90	Varies	Staggered	F-87-06
9	22nd Street	Craycroft Road	Kohl Road	May-67	2.0	400 HPS	120	2.0	Staggered	F-63-04
10	22nd Street	Kohl Road	Pantano Road	Oct-88	1.0	400 HPS	105	9.0	Staggered	F-87-07
11	22nd Street	Pantano Pkwy	Camino Seco	Oct-90	1.0	400 HPS	100	9.0	Staggered	I-87-28
12	29th Street	Alvernon Way	Swan Road	Jan-90	1.0	400 HPS	110	9.0	Staggered	I-85-45
13	29th Street	Swan Road	Craycroft Road	Jun-96	1.0	400 HPS	120	8.0	Staggered	I-85-45
14	29th Street	Craycroft Road	Wilnot Road	1998	1.0	250 HPS	150	8.0	One Side	F-2000-05
15	36th Street	Campbell Avenue	Country Club Road	Since 1994*	1.0	400 HPS	150	9.0	Staggered	F-91-01
16	6th Avenue	Grant Road	Drachman Street	Nov-88	0.7	400 HPS	182	8.0	Staggered	I-85-37
17	6th Avenue	Broadway Blvd	13th Street	Pre-1983	0.2	400 HPS	40	1.0	Staggered	F-87-05
18	6th Avenue	17th Street	25th Street	Sep-83	0.7	400 HPS	150	Varies	Staggered/One Side	F-82-07
19	6th Avenue	I-10	Irvington Street	Sep-83	1.6	250 HPS	180	2.0	Staggered	F-82-02
20	6th Street	Church Avenue	Stone Avenue	Pre-1983	0.2	400/250 HPS	300	1.0	Staggered	
21	6th Street	Stone Avenue	Euclid Avenue	Not Found	0.8	Ornamental	120	4.0	Staggered	F-82-14
22	6th Street	Euclid Avenue	Campbell Avenue	Sep-93	0.9	400 HPS	110		Staggered	F-89-05
23	6th Street	Campbell Avenue	Tucson Blvd	Jan-83	0.5	400 HPS	200	2.0	Staggered	F-82-16
24	6th Street	Tucson Blvd	Country Club Road	Jan-82	0.5	250 HPS	150	15.0	Staggered	F-84-03
25	Ajo Way	La Cholla Blvd	Santa Cruz River	Since 1994*	1.2		120	6.0	Staggered	F-99-02
26	Ajo Way	16th Avenue	12th Avenue	Mar-86	0.3	400 HPS	110	8.8	Staggered	F-85-09
27	Ajo Way	12th Avenue	Benson Highway	Mar-86	1.4	400 HPS	110	8.8	Staggered	F-85-09
28	Ajo Way	Kino Parkway	Country Club Road	Jun-96	0.9	400 HPS	110	9.0	Staggered	F-87-30
29	Alameda Street	Granada Avenue	Post-1983	0.2	400 HPS	115	3.0	One Side	I-82-46	

HPS - High Pressure Sodium
MV - Mercury Vapor

Exhibit 1 (continued)
EXISTING OR IN-DESIGN STREET LIGHTING SYSTEMS

No.	Street Name	From Street	To Street	Date Built	Length (Miles)	Wattage & Type	Average Spacing (Feet)	Typical Setback (Feet)	Pole Placement	City Project No.
30	Alameda Street	Granada Avenue	Toole Avenue	Sep-88	0.5	400 HPS	125	Varies	Staggered	F-87-05
31	Alvernon Way	Ft. Lowell Road	Grant Road	Jan-88	1.0	400 HPS	155	8.0	One Side	I-81-29
32	Alvernon Way	Grant Road	Speedway Blvd	Jan-88	1.0	400 HPS	150	8.0	One Side	F-84-17
33	Alvernon Way	Speedway Blvd	5th Street	May-96	0.5	400 HPS	105	9.0	Staggered	F-94-01
34	Alvernon Way	5th Street	Broadway Blvd	Feb-90	0.5	400 HPS	100	9.0	One Side	F-89-02
35	Alvernon Way	Broadway Blvd	22nd Street	Dec-73	1.0	400 HPS	80	Staggered	F-72-01	
36	Alvernon Way	22nd Street	33rd Street	Jul-83	0.7	400 HPS	100	2.0	Staggered	F-80-003
37	Alvernon Way	29th Street	Aviation Parkway	Oct-86	0.7	400 HPS	Varies	Varies	Staggered/One Side	I-85-20
38	Benson Highway	44th Street	Park Avenue	<i>Post-1983</i>	0.3		150	4.0	One Side	
39	Benson Highway	Kino Parkway	Irvington/Tucson	Jul-97	0.5		100	8.0	Staggered	I-97-56
40	Benson Highway	Irvington Road	Treat Avenue	Jul-97	0.3		100	8.0	Staggered	I-97-56
41	Broadway Blvd	Congress Street	Church Avenue	<i>Pre-1983</i>	0.2		100	3.0	Median/One Side	F-85-05
42	Broadway Blvd	Church Avenue	1st Avenue	Mar-86	0.6	400 HPS	80	2.0	Both Sides	F-85-05
43	Broadway Blvd (EB)	4th Avenue	Aviation Parkway	Jun-96	0.4	150 HPS	60	4.0	One Side	I-92-32
44	Broadway Blvd (WB)	4th Avenue	Aviation Parkway	Jun-96	0.4	150/250 HPS	120	4.0	One Side	I-92-32
45	Broadway Blvd	Aviation Parkway	Park Avenue	Jun-96	0.4	250/400 HPS	170	10.0	Staggered	I-92-32
46	Broadway Blvd	1st Avenue	Country Club Road	May-74	2.0	<i>Details in Special Provisions</i>				
47	Broadway Blvd	Country Club Road	Columbus Blvd	Apr-74	1.5	400 HPS	85	2.0	Staggered	F-72-02
48	Broadway Blvd	Columbus Blvd	Craycroft Road	Mar-69	1.5	700 MV	100	2.0	Staggered	F-67-04
49	Broadway Blvd	Craycroft Road	Kolb Road	Nov-84	2.0	400 HPS	100	9.0	Staggered	F-84-06
50	Broadway Blvd	Kolb Road	Pantano Road		1.0					F-2001-02
51	Camino Seco	Wrightstown Road	Speedway Blvd	<i>In Design</i>	0.6					
52	Camino Seco	Speedway Blvd	Broadway Blvd	Jul-89	1.0	400 HPS	90	9.0	Staggered	I-85-40
53	Camino Seco	Broadway Blvd	22nd Street	Aug-87	1.0	400 HPS	110	9.0	Staggered	I-86-27
54	Campbell Avenue	River Road	Roger Road	<i>In Design</i>	0.6					
55	Campbell Avenue	Roger Road	Prince Road	Oct-96	0.5	400 HPS	125	9.0	Staggered	F-88-01
56	Campbell Avenue	Prince Road	Glenn Street	Sep-87	1.0	400 HPS	150	6.5	Staggered	F-85-17
57	Campbell Avenue	Glenn Street	Grant Road	Jan-83	0.4	400 HPS	110	2.0	Staggered	I-82-43

HPS - High Pressure Sodium
 MV - Mercury Vapor

Exhibit 1 (continued)

EXISTING OR IN-DESIGN STREET LIGHTING SYSTEMS

No.	Street Name	From Street	To Street	Date Built	Average Typical			City Project No.
					Type	(Feet)	Setback (Feet)	
58	Campbell Avenue	Grant Road	Elm Street	<i>In Design</i>	0.5			I-99-37
59	Campbell Avenue	Lester Street	2nd Street	Jun-79	0.6	250 HPS	100	2.0 Staggered
60	Campbell Avenue	2nd Street	6th Street	Apr-82	0.4	400 HPS	75	2.0 Staggered
61	Campbell Avenue	Drexel Road	Ajo Way	Sep-90	2.0	400 HPS	120	9.0 Staggered
62	Church Avenue	6th Street	Perry Avenue	<i>Pre-1983</i>	0.1		300	1.0 Staggered
63	Church Avenue	Perry Avenue	Pennington Street	<i>Pre-1983</i>	0.3	400 HPS	75	2.0 Staggered
64	Church Avenue	Pennington Street	Cushing Street	<i>Pre-1983</i>	0.4	400 HPS	120	6.0 Staggered
65	Columbus Blvd	Fort Lowell Road	Grant Road	Not Found	1.0		180	5.0 One Side
66	Columbus Blvd	5th Street	Broadway Blvd	Not Found	0.5		150	1.0 One Side
67	Congress Street	Silverbell Road	Grande Avenue	May-69	0.3	400 MV	200	2.0 Staggered
68	Congress Street	Grande Avenue	I-10	Mar-96	0.4	250 HPS	60	2.0 Staggered
69	Congress Street	I-10	Granada Avenue	Oct-85	0.3	400 HPS	125	12.0 Opposite
70	Congress Street	Granada Avenue	Church Avenue	Sep-85	0.2	250 HPS	80	2.0 One Side
71	Congress Street	Church Avenue	4th Avenue	Sep-85	0.3	250 HPS	80	2.0 Staggered
72	Country Club Road	Ft. Lowell Road	Glen Street	Sep-88	0.5	400 HPS	210	6.0 Single Side
73	Craycroft Road	Grant Road	Speedway Blvd	May-88	1.0	400 HPS	125	6.0 Staggered
74	Craycroft Road	Speedway Blvd	Broadway Blvd	Feb-84	1.0	400 HPS	90	2.0 Staggered
75	Craycroft Road	Broadway Blvd	22nd Street	Jan-84	1.0	400 HPS	80	2.0 Staggered
76	Craycroft Road	22nd Street	Golf Links Road	Apr-87	1.0	400 HPS	140	Varies Staggered
77	Cushing Street	Granada Avenue	Stone Avenue	<i>Post-1983</i>	0.4	400 HPS	60	2.0 One Side
78	Drachman Avenue	Oracle Road	Stone Avenue	<i>Post-1983</i>	0.4	250 HPS	60	6.0 Staggered
79	Escalante Road	Kohl Road	Pantano Road	Nov-90	1.0	400 HPS	105	9.0 Staggered
80	Euclid Avenue	Grant Road	Speedway Blvd	Jun-93	1.0	400 HPS	150	6.5 Staggered
81	Euclid Avenue	Speedway Blvd	17th Street	<i>In Design</i>	1.5			F-82-05
82	Flowing Wells Road	Roger Road	Miracle Mile	Jun-88	1.3	400 HPS	120	9.0 Staggered
83	Fort Lowell Road	Country Club Road	Columbus Blvd	Jan-89	1.5	400 HPS	120	8.5 Staggered
84	Glenn Street	Fairview Avenue	Oracle Road	2001	0.5		130	7.0 One Side
85	Glenn Street	1st Avenue	Campbell Avenue	Oct-90	1.0	250 HPS	150	6.0 One Side
86	Glenn Street	Campbell Avenue	Tucson Boulevard	<i>Pre-1983</i>	0.5	250 HPS	250	2.0 One Side

HPS - High Pressure Sodium
MV - Mercury Vapor

Exhibit 1 (continued)

EXISTING OR IN-DESIGN STREET LIGHTING SYSTEMS

No.	Street Name	From Street	To Street	Date Built	Length (Miles)	Wattage & Type	Average Spacing (Feet)	Typical Setback (Feet)	Pole Placement	City Project No.
87	Golf Links Road	Alvernion Way	Craycroft Road	In Design	2.0					F-2001-04
88	Golf Links Road	Craycroft Road	Pantano Road	Jan-85	1.0	400 HPS	110	8.0	Staggered	F-84-05
89	Golf Links Road	Pantano Pkwy	Harrison Road	Jan-98	1.1	400 HPS	80	8.0	Staggered	I-89-21
90	Granada Avenue	St. Mary's Road	Broadway Blvd	Aug-84	0.4	400 HPS	125	3.8	Both Sides	I-82-46
91	Granada Avenue	Broadway Blvd	Clark Street	Jan-89	0.4	400 HPS	75	9.0	Staggered	I-87-50
92	Grande Avenue	Speedway Blvd	Saint Mary's Road	Jul-79	0.4	250 HPS	150	2.5	Staggered	F-78-002
93	Grande Avenue	Saint Mary's Road	Franklin Street	Apr-95	0.4	400 HPS	125	8.0	One Side	F-88-08
94	Grande Avenue	Franklin Street	Congress	May-69	0.3	400 MV	90	2.5	Staggered	F-68-01
95	Grant Road	Silverbell Road	Santa Cruz River	Aug-93	1.0	400 HPS	80	8.0	Staggered	F-88-02
96	Grant Road	I-10	Miracle Mile	Apr-87	0.8	400 HPS	105	8.0	Staggered	F-85-013
97	Grant Road	Oracle Road	Stone Avenue	Jun-69	0.3	400 MV	90	2.5	Staggered	F-68-03
98	Grant Road	Stone	Campbell Avenue	Oct-83	1.7	400 HPS	170	5.0	One Side	F-82-06
99	Grant Road	Campbell Avenue	Alvernion Road	Jun-83	1.9	400 HPS	300	2.0	Staggered	F-80-05
100	Grant Road	Alvernion Way	Swan Road	Jun-83	0.9	400 HPS	175	2.0	One Side	F-80-05
101	Grant Road	Swan Road	Wilmett Road	Dec-85	2.0	400 HPS	80	2.0 & 9.0	Staggered	F-84-07
102	Grant Road	Wilmett Road	Tanque Verde Road	Oct-87	0.5	400 HPS	80	9.0	Staggered	F-85-08
103	Harrison Road	Speedway Blvd	Golf Links Road	In Design	3.0					
104	Irvington Road	Mission Road	Santa Cruz River	Aug-93	0.8	400 HPS	100	9.0	Staggered	I-89-31
105	Irvington Road	I-19	6th Avenue	May-87	1.0	400 HPS	140	9.0	Staggered	I-84-41
106	Irvington Road	Kino Parkway	Benson Highway	Sep-90	0.4	400 HPS	120	9.0	Staggered	I-87-73
107	Irvington Road	Benson Highway	I-10	Apr-97	0.8	400 HPS	120	9.0	Staggered	I-88-38
108	Kenyon Drive	Pantano Road	Camino Seco	Pre-1983	1.1	150 HPS	300	3.0	One Side	F-65-2
109	Kino Parkway	6th Street	Winsett Street	Jun-85	1.0	400 HPS	90	8.5	Staggered	I-85-48
110	Kino Parkway	Winsett Street	22nd Street	Jun-85	0.5	400 HPS	105	8.5	Staggered	I-81-56
111	Kino Parkway	22nd Street	Irene Vista	Jun-85	1.6	400 HPS	100	8.5	Staggered	I-81-57
112	Kino Parkway	Irene Vista	Benson Highway	Jun-85	1.1	250 HPS	100	8.5	Staggered	I-81-58
113	Kino Parkway	Benson Highway	Valencia Road	Apr-86	2.4		115	9.0	Staggered	I-81-59
114	Kolb Road	Tanque Verde Road	Speedway Blvd	Nov-87	0.8	400 HPS	105	9.0	Staggered	F-85-14
115	Kolb Road	Speedway Blvd	22nd Street	2001	2.0		90	8.0	Staggered	F-2000-01
116	Kolb Road	22nd Street	Irvington Road	Jun-86	3.0	400 HPS	100	9.0	Staggered	F-84-09

HPS - High Pressure Sodium
MV - Mercury Vapor

Exhibit 1 (continued)

EXISTING OR IN-DESIGN STREET LIGHTING SYSTEMS

No.	Street Name	From Street	To Street	Date Built	Length (Miles)	Wattage & Type	Average Spacing (Feet)	Typical Setback (Feet)	Pole Placement	City Project No.
117	Main Avenue	Drachman Street	St. Mary's Road	Jan-96	0.8	400 HPS	140	8.0	Staggered/One Side	F-88-04
118	Miracle Mile	Oracle Road	I-10	Pre-1983	1.5	250 HPS	60	2.0	Median	I-89-01
119	Mission Road	22nd Street	36th Street	Nov-86	1.2	400 HPS	105	9.0	Staggered	I-82-57
120	Mission Road	36th Street	Ajo Way	Apr-89	0.9	400 HPS	90	9.0	Staggered	I-84-40
121	Mountain Avenue	Roger Road	Ft. Lowell Road	<i>In Design</i>	1.0					I-2000-64
122	Mountain Avenue	Ft. Lowell Road	Grant Road	2002	1.0					I-95-37
123	Mountain Avenue	Grant Road	Speedway Blvd	Feb-92	0.9	400 HPS	Varies	Varies	Staggered	I-85-43C
124	Oracle Road	River Road	Roger Road	Nov-88	1.2	400 HPS	90	9.0	Staggered	F-87-04
125	Oracle Road	Roger Road	Miracle Mile	Jun-86	1.3	400 HPS	90	9.0	Staggered	I-85-12
126	Oracle Road	Miracle Mile	Glenn Street		0.4	250 HPS	150	6.0	Median	I-89-01
127	Oracle Road	Glenn Street	Drachman Street	Feb-91	1.2	400 HPS	100	11.0	Staggered	I-88-42
128	Pantano Parkway	22nd Street	Golf Links Road	May-96	1.3	400 HPS	100	7.0	Staggered	I-88-45
129	Pantano Road	Wrightstown Road	Speedway Blvd	Jul-92	1.0	400 HPS	150	9.0	Staggered	I-86-31
130	Pantano Road	Speedway Blvd	22nd Street	<i>In Design</i>	2.0					F-2001-03
131	Pantano Road	22nd Street	S. Research Loop	Not Found	0.5	Ornamental	125	2.0	Staggered	
132	Pantano Road	Golf Links Road	Escalante Road	2001	1.0		100	9.0	Staggered	I-99-36
133	Pantano Road	Escalante Road	Irvington Road	2002	1.0		120	8.0	Staggered	F-2001-07
134	Park Avenue	Broadway Blvd	18th Street	Oct-94	0.7	400 HPS	100	Varies	Staggered	I-92-33
135	Park Avenue	18th Street	36th Street	Post-1983	1.5	400 HPS	170	2.3	Staggered	I-72-41
136	Park Avenue	36th Street	Ajo Way		1.0	400 HPS	150	8.0	Staggered	
137	Park Avenue	Irvington Road	Valencia Road	<i>In Design</i>	2.0					
138	Pima Street	Swan Road	Craycroft Road	2001	1.0		150	8.0	Staggered	I-85-83
139	Pima Street	Craycroft Road	Wilmett Road	Sep-91	1.0	400 HPS	120	8.0	Staggered	I-85-74
140	Prince Road	I-10	1st Avenue	2000	3.0		140	6.0	Staggered	F-95-02
141	Prince Road	1st Avenue	Campbell Avenue	Apr-87	1.0	400 HPS	100	9.0	Staggered	I-79-23
142	Rita Road	Old Vail Road	Houghton Road	Feb-88	3.1	400 HPS	105	9.0	Staggered	F-89-08
143	Roger Road	Oracle Road	1st Avenue	Dec-86	1.0	250 HPS	120	6.3	One Side	I-85-41
144	Romero Road	Miracle Mile	Prince Road	Jun-87	0.8	400 HPS	170	9.0	One Side	I-83-38
145	Saint Mary's Road	Silverbell Road	Camino Santiago	2000	0.6		120	9.0	Staggered	F-98-07

HPS - High Pressure Sodium
MV - Mercury Vapor

Exhibit 1 (continued)

EXISTING OR IN-DESIGN STREET LIGHTING SYSTEMS

No.	Street Name	From Street	To Street	Date Built	(Miles)	Type	(Feet)	Average Spacing & Setback	Pole Placement	City Project No.
146	Saint Mary's Road	Silverbell Road	I-10	Aug-91	0.8	400 HPS	115	6.0	Staggered	F-88-08
147	Saint Mary's Road	I-10	Granada Avenue	Nov-63	0.3	Unknown	110	4.0	Staggered	F-63-3
148	Saint Mary's Road	Granada Avenue	Church Street	<i>In Design</i>	0.2				Staggered	
149	Silverbell Road	Ironwood Hills	Speedway Blvd	Mar-93	1.2	400 HPS	100	9.0	Staggered	I-90-54
150	Silverbell Road	Speedway Blvd	St. Mary's Road	Oct-91	0.6	400 HPS	125	9.0	Staggered	I-85-39
151	Silverlake Road	Mission Road	I-10	<i>1999</i>	1.0		100	8.0	Staggered	I-88-48
152	Speedway Blvd	Silverbell Road	I-10	Sep-90	1.2	400 HPS	120	9.0	Staggered	I-84-44
153	Speedway Blvd	I-10	Main Avenue	Apr-64	0.3	400 MV	110	6.0	Staggered	I-65-41
154	Speedway Blvd	Main Avenue	Stone Avenue	Sep-87	0.4	400 HPS	105	8.3	Staggered	I-83-22
155	Speedway Blvd	Stone Avenue	Euclid Avenue	Nov-83	0.7	400 HPS	170	2.0	Staggered	F-82-03
156	Speedway Blvd	Euclid Avenue	Country Club Road	Aug-83	1.9	400 HPS	140	6.0	Staggered	F-80-04
157	Speedway Blvd	Tucson Blvd	Alvernon Way	Sep-94	1.5	400 HPS	85	8.0	Staggered	I-87-32
158	Speedway Blvd	Alvernon Way	Swan Road	Sep-87	1.0	400 HPS	150	Varies	Staggered/Median	F-84-18
159	Speedway Blvd	Swan Road	Sahuara Avenue	Jun-85	1.5	400 HPS	170	Varies	Median	F-85-04
160	Speedway Blvd	Sahuara Avenue	Wilmett Road	Aug-86	0.5	400 HPS	170	Varies	Median	F-86-03
161	Speedway Blvd	Wilmett Road	Kolb Road	Sep-86	1.0	400 HPS	94	Varies	Staggered	F-85-06
162	Speedway Blvd	Kolb Road	Pantano Road	Mar-88	1.0	400 HPS	75	9.0	Staggered	F-87-01
163	Speedway Blvd	Pantano Road	Camino Seco	Jan-90	1.0	400 HPS	90	9.0	Staggered	I-86-20
164	Stella Road	Calle Polar	Mann Avenue	<i>2000</i>	0.3		150	8.0	Median	
165	Stella Road	Mann Avenue	Kolb Road	<i>2000</i>	0.5		120	7.0	One Side	
166	Stone Avenue	River Road	Wetmore Road	Jun-91	0.6	400 HPS	100	9.0	Staggered	I-87-35
167	Stone Avenue	Wetmore Road	Limberlost Road	Jan-94	0.2	400 HPS	90	9.0	Staggered	I-92-14
168	Stone Avenue	Wetmore Road	Prince Road	Sep-85	1.0	400 HPS	90	9.0	Staggered	F-84-11
169	Stone Avenue	Prince Road	Drachman Street	Jul-86	2.2	400 HPS	110	6.0	Staggered	F-86-14
170	Stone Avenue	Drachman Street	6th Street	Jan-50	0.7	360 HPS	180	2.0	Staggered	I-471
171	Stone Avenue	6th Street	18th Street	Mar-54	1.0	360 HPS	75	2.0	Staggered	I-471
172	Swan Road	Speedway Blvd	Sep-96	2.0	400 HPS	140	9.0	Staggered	F-95-01	
173	Swan Road	Speedway Blvd	Golf Links Road	Aug-92	2.5	400 HPS	105	9.0	Staggered	F-88-06
174	Tanque Verde Road	Pima Street	Kolb/Grant Road	Aug-94	0.5	400 HPS	70	9.0	Staggered	I-86-66
175	Tanque Verde Road	Kolb/Grant Road	Sabino Canyon Road	Dec-86	0.4	400 HPS	90	9.0	Staggered	F-85-11

HPS - High Pressure Sodium
MV - Mercury Vapor

Exhibit 1 (continued)

EXISTING OR IN-DESIGN STREET LIGHTING SYSTEMS

No.	Street Name	From Street	To Street	Date Built	Length (Miles)	Wattage & Type	Average Spacing (Feet)	Typical Setback (Feet)	Pole Placement	City Project No.
176	Tanque Verde Road	Sabino Canyon Road	Camino Pio Decimo	Jun-93	0.6	400 HPS	100	9.0	Staggered	F-88-05
177	Tanque Verde Road	Camino Pio Decimo	Tanque Verde Wash	<i>Post-1983</i>	0.8		100	4.0	Staggered	
178	Toole Avenue	Alameda Street	Broadway Blvd	<i>Post-1983</i>	0.3		200	2.0	Sporadically	I-97-45
179	Tucson Blvd	Grant Road	Speedway Blvd	<i>Post-1983</i>	1.0	400 HPS	150	6.0	One Side	F-88-07
180	Tucson Blvd	Speedway Blvd	Broadway Blvd	<i>Pre-1983</i>	1.0	varies		2.0	Sporadically	F-64-06
181	Tucson Blvd**	Broadway Blvd	22nd Street	Since 1994*	1.0	400 HPS	175	2.0	Staggered	I-85-35*
182	Tucson Blvd	Irvington Road	Bantam Road	Not Found	0.5	400 HPS	100	8.0	Staggered	
183	Tucson Blvd	Bantam Road	Valencia Road	Feb-86	1.4	400 HPS	120	9.0	Staggered	I-81-59B
184	Tucson Blvd	Valencia Road	Corona Road	Mar-86	1.0	400 HPS	125	8.0	Staggered	F-84-14
185	University Boulevard	6th Avenue	1st Avenue	Apr-95	0.4	250 HPS	130	2.0	Both Sides	F-91-004
186	Valencia Road	I-19	Santa Clara Avenue	<i>2002</i>	0.3	100 HPS	100	5.0	One Side	
187	Valencia Road	Santa Clara Avenue	12th Avenue	<i>2002</i>	0.2	100 HPS	100	8.0	Staggered	
188	Valencia Road	12th Avenue	Old Nogales Hwy	Jun-95	0.9	400 HPS	100	9.0	Staggered	F-87-02A
189	Valencia Road	Old Nogales Hwy	Country Club Road	Jan-96	2.0	400 HPS	105	8.0	Staggered	F-87-02B
190	Wilmett Road	Pima Street	Speedway Blvd	Jun-86	0.5	400 HPS	110	9.0	Staggered	I-84-42
191	Wilmett Road	Speedway Blvd	Broadway Blvd	Sep-87	1.0	400 HPS	100	14.0	Staggered	F-85-07
192	Wilmett Road	Broadway Blvd	Golf Links Road	<i>2002</i>	2.0		80	9.0	Staggered	F-2000-04
193	Wilmett Road	Golf Links Road	Nicaragua Street	Dec-88	0.7	400 HPS	Varies	9.0	Staggered/One Side	I-86-84
194	Sarnoff	Broadway Blvd	22nd Street	Post-1983	1.1	150 HPS	280	3.0	One Side	

*Improved since Phase III per 9/4/01 correspondence from COT Project Manager
As-built for segments with "Not Found" were not found on the Transview website.

As-built with project numbers, but no other information were not available for viewing on the Transview website.
Information in Large, Bold, Italic was provided in 12/28/01 correspondence from COT Project Manager
Information was gathered based on existing sources. Setbacks and spacings were field measured when as-built data was not available.

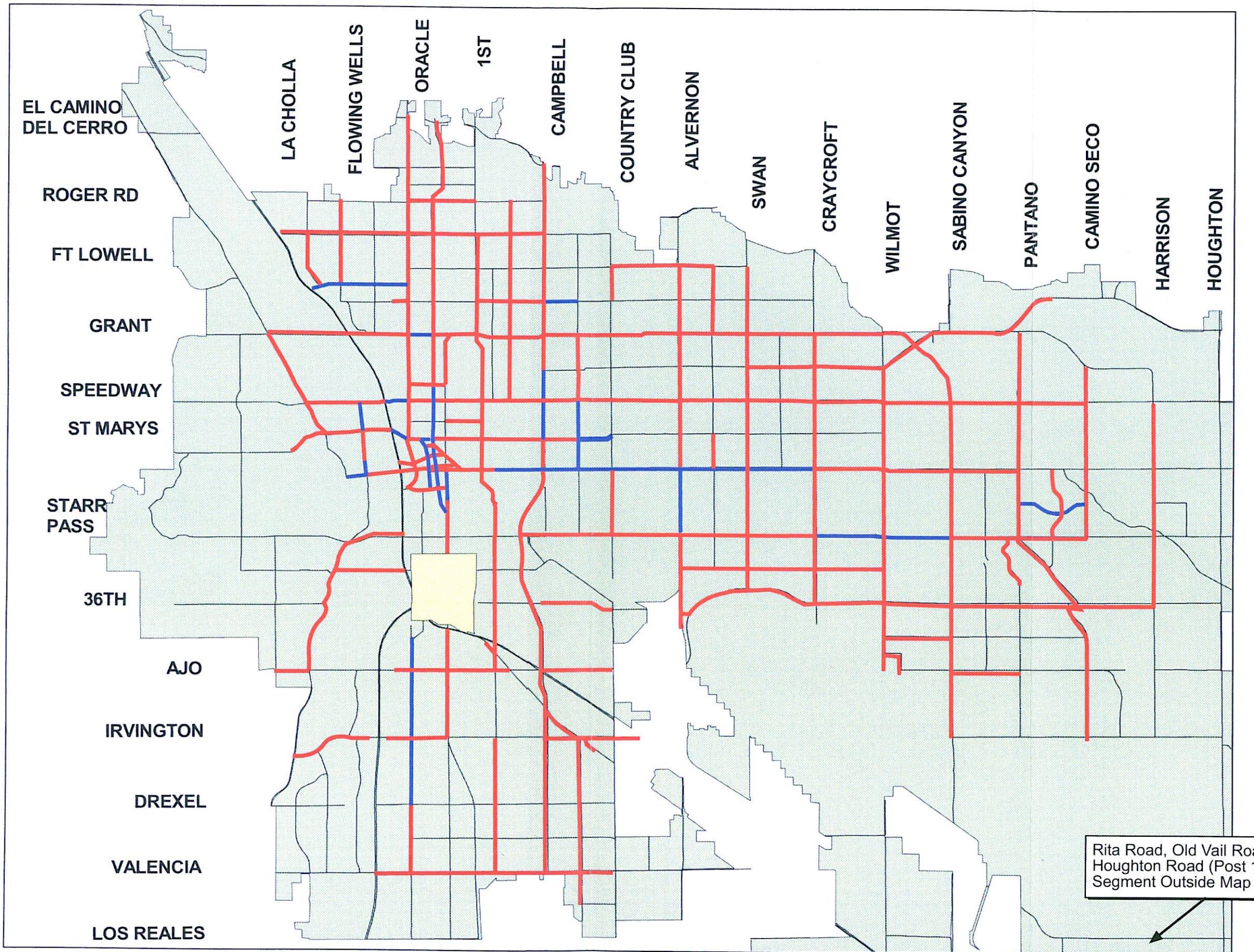


Exhibit 2

Existing Street Lighting System Map

3. ACCIDENT ANALYSIS

Traffic accident information provides the basis of the system by which roadway segments are selected for the installation of roadway lighting in the City of Tucson. Traffic accident information was provided by the City of Tucson for this study for all arterial and collector roadways for the three year period 1999-2001. The accident information for the unlit arterial and collector segments included in this project is provided in Appendix A. This chapter provides a number of lists of roadway segments that have been sorted based on different measures of accident rates pertinent to nighttime accident histories.

TRAFFIC ACCIDENT MEASURES

Traffic accidents occurring on roadway segments may be measured by a number of different criteria. These include: (1) accident rates which measure the rate of accidents over a given length of roadway per million vehicle miles (MVM) traveled on that segment; (2) accident frequencies which measure the number of accidents over a given length of time and a given length of segment; and (3) rate ratios which are ratios of an accidents rate from one specific time period over the accident rate from a different time period. Of particular interest to this study are the measures that relate to nighttime accidents and the ratio of nighttime to daytime accidents on unlit collectors and arterials. On the following pages are six tables that provide a list of the highest accident locations as measured by six different accident measures. These accident measures are discussed below.

Night Accident Frequency

This rate represents the number of nighttime accidents per year per mile of length on the segment. This measure provides an indication of the total number of accidents on a segment, without regard to the amount of traffic on that segment. The highest Night Accident Frequency unlit locations are listed in Exhibit 3.

Night Accident Rate

This measure is calculated by measuring the number of nighttime accidents per year per million vehicle miles (MVM) on the segment, for traffic traveling during nighttime hours. For the purpose of this study, it was assumed that nighttime hours include the hours between 6:00 PM and 6:00 AM. No adjustment in hours was made for summer months (fewer “dark” hours)

or winter months (more “dark” hours). The highest nighttime accident rate unlit segments are listed in Exhibit 4.

Rate Ratio (Night/Day)

This measure provides an indication of nighttime accident rates relative to accident rates occurring during the day. It is calculated by dividing the nighttime accident rate by the daytime accident rate. It should be recognized that because of the fact that nighttime travel is inherently more dangerous than daytime travel, a higher accident rate ratio does not necessarily indicate a problem on a segment for nighttime travel. Exhibit 5 lists those unlit segments with the highest rate ratios.

Accident Frequency Ratio (Night/Day)

This measure provides an indication of the percentage of overall accidents occurring during nighttime hours. It is calculated by dividing the nighttime accident frequency by the daytime accident frequency. It should be recognized that because of the fact that nighttime travel is inherently more dangerous than daytime travel, a higher accident ratio does not necessarily indicate a problem on a segment for nighttime travel. Exhibit 6 provides a summary of the highest accident ratio unlit segments.

Total Accident Frequency

Accident frequency is measured on a segment per mile per year, providing an indication of locations where the largest number of accidents occurs. Exhibit 7 provides a listing of these unlit segments. Because this measure does not account for the volume of traffic on a segment, it would be expected that high volume roadways would rank relatively high on this list.

Total Rate

This measure is similar to total accident frequency, except that it accounts for the volume from a segment. Because it is calculated from the total number of accidents, it provides a measure of the overall safety characteristics of the roadway segments. The listing of the highest accident rate unlit segments from this study is provided in Exhibit 8.

Exhibit 3
TWENTY HIGHEST NIGHT ACCIDENT FREQUENCIES
UNLIT SEGMENTS

Segment	On Street	From Street	To Street	Distance (Miles)	Night Accident Frequency
70	Valencia Road	Oak Tree Drive	I-19	1.0	14.67
69	Valencia Road	City Limits	Oak Tree Drive	0.5	13.33
55	Irvington Road	6 th Avenue	Park Avenue	0.7	11.43
56	Irvington Road	Park Avenue	Campbell Avenue	0.7	11.43
41	22 nd Street	6 th Avenue	Kino Parkway	1.1	10.30
15	Ft. Lowell Road	Campbell Avenue	Country Club Road	1.0	8.67
36	Broadway Boulevard	Pantano Road	Camino Seco	1.0	8.33
93	6 th Avenue	Drachman Street	Speedway Boulevard	0.2	8.33
40	22 nd Street	I-10	6 th Avenue	0.6	7.78
111	Country Club Road	Glenn Street	Grant Road	0.5	7.33
13	Ft. Lowell Road	Oracle Road	First Avenue	1.0	7.00
14	Ft. Lowell Road	First Avenue	Campbell Avenue	1.0	6.67
113	Country Club Road	Speedway Boulevard	Broadway Boulevard	1.0	6.67
98	Nogales Highway	6 th Avenue	Drexel Road	1.0	6.33
24	Wrightstown Road	Tanque Verde Road	Wrightstown Terrace	0.6	6.11
37	Broadway Boulevard	Camino Seco	Harrison Road	1.0	5.67
101	Park Avenue	Grant Road	Speedway Boulevard	1.0	5.33
7	Wetmore Road	Oracle Road	First Avenue	1.0	5.00
126	Swan Road	City Limits	Ft. Lowell Road	0.4	5.00
110	Country Club Road	Prince Road	Ft. Lowell Road	0.5	4.67

Night Accident Frequency: Number of nighttime accidents/year/mile.

Exhibit 4
TWENTY HIGHEST NIGHT ACCIDENT RATES
UNLIT SEGMENTS

Segment	On Street	From Street	To Street	Distance (Miles)	Night Accident Rate
31	University Boulevard	Main Avenue	6 th Avenue	0.5	30.44
142	Prudence Road	Broadway Boulevard	22 nd Street	1.0	26.86
104	Campbell Avenue	Winsett Street	Aviation Parkway	0.4	22.83
20	Glenn Street	Country Club Road	Alvernon Way	1.0	9.13
93	6 th Avenue	Drachman Street	Speedway Boulevard	0.2	8.78
120	Alvernon Way	Prince Road	Ft. Lowell Road	0.7	8.70
54	Escalante Road	Camino Seco	Pantano Creek	0.6	7.61
44	Fairland Stravenue	Cherrybell Stravenue	Country Club Road	1.3	7.02
17	Glenn Street	Flowing Wells Road	Fairview Avenue	0.4	6.85
61	Drexel Road	I-19	12 th Avenue	0.5	6.45
66	Bilby Road	Nogales Highway	Campbell Avenue	1.1	6.23
97	6 th Avenue	Drexel Road	Valencia Road	1.0	5.48
24	Wrightstown Road	Tanque Verde Road	Wrightstown Terrace	0.6	5.07
18	Glenn Street	Oracle Road	Stone Avenue	0.4	4.81
139	Harrison Road	Golf Links Road	Escalante Road	1.0	4.15
123	Columbus Boulevard	Speedway Boulevard	5 th Street	0.5	4.06
127	Rosemont Boulevard	Grant Road	Speedway Boulevard	1.0	4.06
98	Nogales Highway	6 th Avenue	Drexel Road	1.0	4.04
48	Stella Road	Kolb Road	Pantano Road	1.0	3.91
62	Drexel Road	12 th Avenue	Nogales Highway	0.9	3.90

Night Accident Rate: Number of nighttime accidents/year/million vehicle miles (MVM).

Exhibit 5
TWENTY HIGHEST NIGHT/DAY ACCIDENT RATE RATIOS
UNLIT SEGMENTS

Segment	On Street	From Street	To Street	Distance (Miles)	Rate Ratio Night/Day
120	Alvernon Way	Prince Road	Ft. Lowell Road	0.7	13.33
44	Fairland Stravenue	Cherrybell Stravenue	Country Club Road	1.3	5.50
103	Cherrybell Stravenue	22 nd Street	Silverlake Road	0.5	5.45
31	University Boulevard	Main Avenue	6 th Avenue	0.5	5.00
27	Elm Street	Campbell Avenue	Country Club Road	1.0	4.89
96	6 th Avenue	Irvington Road	Drexel Road	1.0	4.74
82	Mission Road	Irvington Road	Drexel Road	0.9	4.58
135	Sarnoff Drive	22 nd Street	Pantano Parkway	0.5	4.50
60	Drexel Road	Mission Road	Santa Cruz River	1.1	3.26
134	Prudence Road	Golf Links Road	Escalante Road	1.0	3.08
79	Silverbell Road	St. Mary's Road	Congress Street	0.8	2.97
76	Silverbell Road	El Camino Del Cerro	Sweetwater Drive	1.1	2.74
83	Oak Tree Drive	Midvale Park Road	Valencia Road	1.8	2.67
84	Midvale Park Road	Irvington Road	Drexel Road	0.9	2.67
38	Old Spanish Trail	Broadway Boulevard	Camino Seco	0.5	2.64
61	Drexel Road	I-19	12 th Avenue	0.5	2.56
22	Glenn Street	Swan Road	Craycroft Road	1.0	2.50
87	Calle Santa Cruz	Irvington Road	Drexel Road	1.0	2.33
142	Prudence Road	Broadway Boulevard	22 nd Street	1.0	2.21
93	6 th Avenue	Drachman Street	Speedway Boulevard	0.2	2.14

Exhibit 6
TWENTY HIGHEST NIGHT/DAY ACCIDENT FREQUENCY RATIOS
UNLIT SEGMENTS

Segment	On Street	From Street	To Street	Distance (Miles)	Freq Ratio Night/Day
60	Drexel Road	Mission Road	Santa Cruz River	1.1	2.00
82	Mission Road	Irvington Road	Drexel Road	0.9	2.00
16	Ft. Lowell Road	Columbus Boulevard	Swan Road	0.6	2.00
120	Alvernon Way	Prince Road	Ft. Lowell Road	0.7	2.00
38	Old Spanish Trail	Broadway Boulevard	Camino Seco	0.5	2.00
96	6 th Avenue	Irvington Road	Drexel Road	1.0	1.83
61	Drexel Road	I-19	12 th Avenue	0.5	1.50
103	Cherrybell Stravenue	22 nd Street	Silverlake Road	0.5	1.50
44	Fairland Stravenue	Cherrybell Stravenue	Country Club Drive	1.3	1.25
27	Elm Street	Campbell Avenue	Country Club Drive	1.0	1.00
76	Silverbell Road	El Camino Del Cerro	Sweetwater Drive	1.1	1.00
135	Sarnoff Drive	22 nd Street	Pantano Drive	0.5	1.00
81	Mission Road	Ajo Way	Irvington Road	1.3	0.90
84	Midvale Park Road	Irvington Road	Drexel Road	0.9	0.83
69	Valencia Road	City Limits	Oak Tree Drive	0.5	0.80
72	Valencia Road	Kolb Road	Old Vail Road	2.3	0.80
26	Wrightstown Road	Camino Seco	Harrison Road	1.0	0.80
98	Nogales Highway	6 th Avenue	Drexel Road	1.0	0.79
66	Bilby Road	Nogales Highway	Campbell Avenue	1.1	0.75
136	Camino Seco	Golf Links Road	Escalante Road	1.1	0.75

Exhibit 7
TWENTY HIGHEST TOTAL ACCIDENT FREQUENCIES
UNLIT SEGMENTS

Segment	On Street	From Street	To Street	Distance (Miles)	Total Accident Frequency
41	22 nd Street	6 th Avenue	Kino Parkway	1.1	62.42
70	Valencia Road	Oak Tree Drive	I-19	1.0	61.67
56	Irvington Road	Park Avenue	Campbell Avenue	0.7	53.33
36	Broadway Boulevard	Pantano Road	Camino Seco	1.0	41.33
111	Country Club Road	Glenn Street	Grant Road	0.5	37.33
113	Country Club Road	Speedway Boulevard	Broadway Boulevard	1.0	35.67
14	Ft. Lowell Road	First Avenue	Campbell Avenue	1.0	35.33
13	Ft. Lowell Road	Oracle Road	First Avenue	1.0	31.67
112	Country Club Road	Grant Road	Speedway Boulevard	1.0	31.67
15	Ft. Lowell Road	Campbell Avenue	Country Club Road	1.0	31.33
55	Irvington Road	6 th Avenue	Park Avenue	0.7	30.00
95	Toole Avenue	6 th Avenue	4 th Avenue	0.3	30.00
69	Valencia Road	City Limits	Oak Tree Drive	0.5	30.00
40	22 nd Street	I-10	6 th Avenue	0.6	26.67
37	Broadway Boulevard	Camino Seco	Harrison Road	1.0	24.00
126	Swan Road	City Limits	Ft. Lowell Road	0.4	23.33
101	Park Avenue	Grant Road	Speedway Boulevard	1.0	21.67
93	6 th Avenue	Drachman Street	Speedway Boulevard	0.2	21.67
35	5 th Street	Craycroft Road	Wilmot Road	1.0	19.00
29	Pima Street	Alvernon Way	Swan Road	1.0	18.33

Total Accident Frequency: Number of total accidents/year/mile.

Exhibit 8
TWENTY HIGHEST TOTAL ACCIDENT RATES
UNLIT SEGMENTS

Segment	On Street	From Street	To Street	Distance (Miles)	Total Accident Rate
142	Prudence Road	Broadway Boulevard	22 nd Street	1.0	14.89
104	Campbell Avenue	Winsett Street	Aviation Parkway	0.4	12.45
17	Glenn Street	Flowing Wells Road	Fairview Avenue	0.4	12.18
18	Glenn Street	Oracle Road	Stone Avenue	0.4	8.93
31	University Boulevard	Main Avenue	6 th Avenue	0.5	8.79
20	Glenn Street	Country Club Road	Alvernon Way	1.0	6.55
101	Park Avenue	Grant Road	Speedway Boulevard	1.0	6.31
94	6 th Avenue	Speedway Boulevard	6 th Street	0.6	5.61
95	Toole Avenue	6 th Avenue	4 th Avenue	0.3	5.41
93	6 th Avenue	Drachman Street	Speedway Boulevard	0.2	5.16
114	Country Club Road	22 nd Street	Aviation Highway	0.6	5.15
111	Country Club Road	Glenn Street	Grant Road	0.5	5.04
56	Irvington Road	Park Avenue	Campbell Avenue	0.7	5.02
41	22 nd Street	6 th Avenue	Kino Parkway	1.1	4.69
54	Escalante Road	Camino Seco	Pantano Creek	0.6	4.57
28	Pima Street	Country Club Road	Alvernon Way	1.0	4.51
70	Valencia Road	Oak Tree Drive	I-19	1.0	4.49
97	6 th Avenue	Drexel Road	Valencia Road	1.0	4.46
66	Bilby Road	Nogales Highway	Campbell Avenue	1.1	4.39
113	Country Club Road	Speedway Boulevard	Broadway Boulevard	1.0	4.27

Total Accident Rate: Number of total accidents/year/million vehicle miles (MVM).

4. WARRANTING AND PRIORITY RANKING ANALYSIS

SUMMARY

Since 1979, the identification and implementation of the roadway lighting capital improvement program (CIP) in Tucson has been based on a two-step analytical analysis that identifies and prioritizes roadway segments for improvement. The first step is a warranting analysis to identify those segments that warrant roadway lighting, based on a number of geometric, operational, environmental, and accident factors. The second step is the prioritization of those segments based on the potential for the reduction of nighttime accidents, that may be expected.

The procedure utilized in this study was initially implemented in Tucson with the Phase I Roadway Illumination Study in 1979. It has been used as the basis for the capital improvement programs that were developed as part of the previous illumination studies, and it remains an effective analytical method. The following sections in this chapter discuss in detail the warranting and prioritization analyses, and provide the prioritized list of roadway segments that served as the basis for development of the recommended capital improvement program contained in Chapter 5.

WARRANTING ANALYSIS

The term warrant, as used in this context, means that an analytical evaluation of the factors for justifying a proposed project has been performed and certain criteria have been met. In this case, the identification of minimum warrants is specific to the City of Tucson at this time, and is based on conditions relative to current roadway and accident characteristics.

It must be noted that the meeting of a warrant for lighting improvements does not obligate a public agency to provide that improvement. The cost of an improvement recommended as a result of a warrant analysis may exceed the available resources to provide the improvement. There are varying degrees of need, and therefore, it is the responsibility of the administrator to allocate resources to the project of greatest need; thus, the necessity of a method of establishing priorities. There may always be intense needs identified that may supersede a developed prioritization, and the allocation of additional resources to meet these needs is a judgement that must be made by the agency administration.

Lighting warrants are based on a number of roadway and traffic characteristics and the needs of the driver. They include factors such as traffic volume, speed, road use during the night, night accident rate, roadway geometrics, and general night visibility. Overall, justification for lighting improvements is based on the potential for lighting to reduce nighttime accidents. This potential is measured in terms of reductions in personal injuries, fatalities, and property damage accidents. More effective usage of the road, the possible increase in its capacity, and other societal factors such as a reduction in crime rate, and the enhancement of astronomy in the area can also be considered but are difficult to quantify, and are not factored into the warrants of this study.

Development of Illumination Warrants

The analysis approach to the development of roadway lighting warrants developed in the Phase I study, and utilized in the Phase II and Phase III studies, was again utilized as part of the analysis of the 142 roadway segments studied in Phase IV. The procedure involved the development of ratings of a number of roadway and roadside characteristics that affect the content and amount of information the driver is subjected to during nighttime driving activities. Exhibit 9 is a sample input form that was utilized during the field data collection task through which each roadway segment was visited and analyzed for each of the listed characteristics.

The characteristics shown in Exhibit 9 are divided into three categories: geometric factors, operational factors, and environmental factors. Each factor may receive a rating of one through five indicating the degree of impact on the amount of information received by the driver. The presence of narrow lanes, horizontal curves, limited sight distance, traffic signals, and similar characteristics provide for a substantially more complicated driving environment, and therefore would tend to benefit more from the provision of continuous roadway lighting.

As can be seen on the form, each of the factors is weighted relative to its impact on the need for lighting. The weighting is provided for both unlit and lighted conditions, with the difference between the two being utilized for the calculation of the warranting score. These factors that receive the highest weighting, and therefore have the most influence on the final score include the amount and sharpness of curves, and the ratio of nighttime to daytime accident rates.

Exhibit 9

FIELD DATA COLLECTION FORM

COMPREHENSIVE ROADWAY ILLUMINATION STUDY - PHASE IV											
SEGMENT NUMBER: ON STREET:	DATE: FROM:	TO:	OBSERVER:								
CLASSIFICATION FACTOR	1	2	3	4	5	COMMENTS	Chosen Factor	UNLIT WEIGHT (A)	LIGHTED WEIGHT (B)	DIFF. (A - B)	SCORE RATING X (A - B)
Geometric Factors:											
No. of Lanes	4 or fewer	-	6	-	8 or more			1.0	0.8	0.2	0.00
Lane Width	more than 12'	12'	11'	10'	less than 10'			3.0	2.5	0.5	0.00
Median Openings per Mile	less than 4 of one-way operation	4 - 8	8 - 12	12 - 15	more than 15 or no access control			5.0	3.0	2.0	0.00
Curb Cuts	less than 10%	10 - 20%	20 - 30%	30 - 40%	more than 40%			5.0	3.0	2.0	0.00
Curves	less than 3°	3 - 6°	6 - 8°	8 - 10°	more than 10°			13.0	5.0	8.0	0.00
Grades	less than 3%	3 - 4%	4 - 5%	5 - 7%	more than 7%			3.2	2.8	0.4	0.00
Sight Distance	more than 700'	500 - 700'	300 - 500'	200 - 300'	less than 200'			2.0	1.8	0.2	0.00
Parking	Prohibited Both Sides	Loading Zones Only	Off-Peak Only	Permitted One Side	Permitted Both Sides			0.2	0.1	0.1	0.00
											Geometric Total = 0.00
Operational Factors:											
Signals - % of Major Intersections	100%	60%	60 - 70%	50%	less than 50%			3.0	2.8	0.2	0.00
Left Turn Lane - % of Major Intersections	100% or one-way travel	80%	60 - 70%	50%	less than 50% or undivided streets			5.0	4.0	1.0	0.00
Median Width	30'	20 - 30'	10 - 20'	4 - 10'	0 - 4'			1.0	0.5	0.5	0.00
Operating Speed	25 or less	30	35	40	45 or greater			1.0	0.2	0.8	0.00
Pedestrian Traffic (Night Peds/Mile)	0	0 - 50	50 - 100	100 - 200	more than 200			1.5	0.5	1.0	0.00
											Operational Total = 0.00
Environmental Factors:											
% Development	0	0 - 30%	30 - 60%	60 - 90%	100%			0.5	0.3	0.2	0.00
Predominant Type of Development	Undeveloped or backup design	Residential	50% Res. &/or Commercial	Strip Ind. Or Comm.	-			0.5	0.3	0.2	0.00
Setback Distance	more than 200'	150 - 200'	100 - 150'	50 - 100'	less than 50'			0.5	0.3	0.2	0.00
Advertising of Area Lighting	None	0 - 40%	40 - 60%	60 - 80%	more than 80%			3.0	1.0	2.0	0.00
Raised Curb Median	None	Continuous	All Intersections	Signalized Intersections	Few Intersections			1.0	0.5	0.5	0.00
											Environmental Total = 0.00
Accidents:											
Ratio of Night-to-Day Accident Rates	less than 1.0	1.0 - 1.2	1.2 - 1.5	1.5 - 2.0	greater than 2.0			10.0	2.0	8.0	0.00
											Accident Total = 0.00
											Geometric Total: 0.00 Operational Total: 0.00 Environmental Total: 0.00 Accident Total: 0.00
											Warranting Score (E_s) = 0.00 points

The total warranting score (E_x) is computed by multiplying the rating of each individual factor by the difference between the unlit and lighted weighting factor, and summing each of the scores to obtain the total warranting score.

It should be noted that the “potential” for lighting improvements to reduce accidents is primarily the basis for justifying lighting improvements. This analysis considers evaluation criteria for a wide range of situations (environmental, geometric and operational) that have the potential to influence the number of accidents under unlit conditions. Therefore, the warranting score, E_x , is a measure of the potential for lighting to reduce the number of nighttime accidents. However this potential is not expressed in economic terms.

Results of Warranting Analysis

A minimum threshold warranting score must be established in order to identify those projects that are determined to warrant roadway lighting improvements. Phases I and II set the minimum warranting score at 75 points. It should be noted that the minimum warranting condition assumed for this analysis is not an inflexible level, but simply provides a starting point for the determination of appropriate projects. The current analysis for roadway segments indicated generally lower scores overall, and therefore the minimum warranting score used for this study was lowered to 50 points. This minimum warranting score of 50 points was also applied in the Phase III study.

The warranting analysis provides the basis for the prioritization of proposed improvements, which is the next phase of the analysis. A complete listing of the individual warrant scores for each roadway segment is provided in Appendix B.

PRIORITY RANKING ANALYSIS

In order to develop a prioritized list of those projects warranting improvement, the cost-effectiveness of providing those improvements should be considered. The priority ranking analysis procedure provides this effectiveness comparison by considering the cost of the lighting improvement, and the amount of nighttime traffic using the facility. These procedures allow the decision-making agency to allocate funds among competing projects in a manner to maximize the benefits to the roadway users.

The technique utilized for calculating the priority ranking is given by the following formula:

$$P_x = \frac{(E_x)(NADT_x)}{AC_x}$$

where: P_x = Priority index for roadway segment "X"
 E_x = Warranting score (effectiveness)
 $NADT_x$ = Nighttime average daily traffic volume for segment "X"
 AC_x = Annualized costs for the lighting improvements (per mile)

A listing of the priority ranking of the roadway segments, with the minimum warrant score of 50, is provided in Exhibit 10.

This ranking provided the basis for the development of the recommended capital improvement program. High ranking roadway segments generally indicate complex nighttime traffic operating conditions, nighttime accident problems, and relatively high nighttime traffic volumes. This list contains both arterial and collector roadways, and no distinction was made between the two as part of this calculation. The recommended capital improvement program, as presented in Chapter 5, utilizes this prioritization analysis extensively.

Exhibit 10
RESULTS OF PRIORITY RANKING ANALYSIS (Warranty Score > 50)

Rank	Seg	On Street	From Street	To Street	Length (miles)	Night ADT (100's)	Warranting Score	Street Class	Priority Score
1	69	W Valencia Road	City Limits	Oak Tree Dr	0.5	117	69.9	A	34.5
2	93	N 6th Avenue	Drachman St	Speedway Bld	0.2	26	79.1	A	23.3
3	55	E Irvington Road	6th Ave	Park Ave	0.7	102	61.4	A	19.8
4	106	E Benson Highway	Treat Ave	Country Club Rd	0.3	33	67.4	A	17.7
5	132	N Sabino Canyon Road	City Limits	Tanque Verde Rd	0.9	123	58.2	A	16.8
6	110	N Country Club Road	Prince Rd	Fort Lowell Rd	0.5	63	54.3	A	15.5
7	24	Wrightstown Rd	Tanque Verde Rd	Wrightstown Terrace	0.6	33	108.0	A	15.0
8	80	S Mission Road	Congress St	22nd St	1.1	64	101.0	A	14.8
9	38	E Old Spanish Trail	Broadway Bld	Camino Seco	0.5	25	100.5	C	12.8
10	6	W Wetmore Road	Fairview Ave	Oracle Rd	0.5	46	60.6	A	12.6
11	131	S Calle Polar	Nicaragua Dr	Escalante Rd	0.3	19	73.1	C	11.8
12	50	E Nicaragua Dr	Wilmot Rd	Calle Polar	0.3	21	65.4	C	11.7
13	79	N Silverbell Road	St Marys Rd	Congress St	0.8	39	101.8	A	11.2
14	13	W Fort Lowell Road	Oracle Rd	1st Ave	1.0	100	50.4	A	11.2
15	82	S Mission Road	Irvington Rd	Drexel Rd	0.9	66	72.2	A	11.1
16	96	S 6th Avenue	Irvington Rd	Drexel Rd	1.0	46	86.6	C	10.2
17	4	E River Road	Dodge Bld	River Oak Tr	0.9	47	83.2	A	9.8
18	41	E 22nd Street	6th Ave	Kino Pkwy	1.1	108	51.8	A	9.8
19	37	E Broadway Boulevard	Camino Seco	Harrison Rd	1.0	72	51.1	A	9.2
20	16	E Fort Lowell Road	Columbus Bld	Swan Rd	0.6	39	62.7	A	9.0
21	25	E Wrightstown Road	Tanque Verde Rd	Camino Seco Rd	0.8	32	89.0	A	9.0
22	98	S Nogales Highway	6th Ave	Drexel Rd	1.0	43	80.8	A	8.5
23	42	E 22nd Street	Camino Seco	Harrison Rd	1.0	60	55.2	A	8.3
24	99	S Nogales Highway	Drexel Rd	Valencia Rd	1.0	43	77.4	A	8.1
25	84	S Midvale Park Road	Irvington Rd	Drexel Rd	0.9	40	76.0	A	8.1
26	81	S Mission Road	Ajo Way	Irvington Rd	1.3	66	72.1	A	7.6
27	12	E Prince Road	Campbell Ave	Country Club Rd	1.0	57	59.0	A	7.6
28	60	W Drexel Road	Mission Rd	Santa Cruz River	1.1	38	88.0	C	7.3
29	32	E 5th Street	Country Club Rd	Alvernon Way	1.0	46	64.3	C	7.1
30	123	N Columbus Boulevard	Speedway Bld	5th St	0.5	18	79.2	C	6.8
31	125	S Columbus Boulevard	22nd St	29th St	0.5	17	80.9	C	6.6
32	5	W El Camino Del Cerro	Silverbell Rd	I-10	0.8	39	52.5	A	6.5
33	52	E Escalante Road	Calle Polar	Kolb Rd	0.8	32	62.2	A	6.3
34	30	E Speedway Boulevard	Camino Seco	Harrison	1.0	47	51.8	A	6.1
35	75	N Silverbell Road	City Limits	El Camino Del Cerro	0.8	33	59.0	A	6.1
36	46	E 36th Street	Country Club Rd	City Limits	0.5	23	57.3	A	6.0
37	61	W Drexel Road	I-19	12th Ave	0.5	17	73.2	C	5.9
38	138	N Harrison Road	Wrightstown Rd	Speedway Bld	0.5	23	50.8	A	5.9
39	19	E Glenn Street	Tucson Bld	Country Club Rd	0.5	18	64.3	C	5.5
40	101	N Park Avenue	Grant Rd	Speedway Bld	1.0	40	53.5	C	5.5
41	29	E Pima Street	Alvernon Way	Swan Rd	1.0	44	50.6	C	5.3
42	76	N Silverbell Road	El Camino Del Cerro	Sweetwater	1.1	27	82.4	A	5.1
43	59	E Irvington Road	Camino Seco	Harrison Rd	1.0	24	79.4	A	4.8
44	17	W Glenn St	Flowing Wells Rd	Fairview Ave	0.4	10	80.2	C	4.8

Street Classes:

A = Arterial

C = Collector

Exhibit 10 (continued)
RESULTS OF PRIORITY RANKING ANALYSIS (Warranty Score > 50)

Rank	Seg	On Street	From Street	To Street	Length (miles)	Night ADT (100's)	Warranting Score	Street Class	Priority Score
45	62	E Drexel Road	12th Ave	Nogales Hwy	0.9	26	69.2	C	4.8
46	130	N Wilmot Road	Grant Rd	Pima St	0.5	16	58.5	C	4.5
47	57	E Irvington Road	Kolb Rd	Pantano Rd	1.0	31	56.8	A	4.4
48	78	N Silverbell Road	Goret Rd	Grant Rd	0.9	27	57.4	A	4.3
49	137	S Camino Seco	Golf Links Rd	Escalante Rd	1.1	22	86.5	C	4.1
50	140	S Harrison Road	Golf Links Rd	Escalante Rd	1.0	22	72.4	A	4.0
51	26	E Wrightstown Road	Camino Seco	Harrison	1.0	22	80.8	A	4.0
52	72	E Valencia Road	Kolb Rd	Old Vail Rd	2.3	42	86.3	A	4.0
53	135	S Sarnoff Drive	22nd St	Pantano Pkwy	0.5	8	103.1	C	3.9
54	105	E Benson Highway	Park Ave	Kino Pkwy	1.1	31	61.9	A	3.7
55	114	S Country Club Road	22nd St	Aviation Hwy	0.6	19	51.3	A	3.7
56	10	W Roger Road	Flowing Wells Rd	Oracle Rd	1.0	27	55.3	C	3.6
57	77	N Silverbell Road	Sweetwater Dr	Goret Rd	1.4	27	70.4	A	3.4
58	64	E Drexel Road	Campbell Ave	Country Club Rd	1.0	20	75.0	A	3.4
59	107	N Tucson Boulevard	Prince Rd	Fort Lowell Rd	0.5	13	51.5	C	3.2
60	103	E Cherrybell Strav	22nd St	Silverlake Rd	0.5	11	54.7	C	3.1
61	140	S Harrison Road	Escalante Rd	Irvington Rd	1.0	22	54.6	A	3.0
62	97	S 6th Avenue	Drexel Rd	Valencia Rd	1.0	15	78.4	C	3.0
63	116	S Country Club Road	Ajo Way	Irvington Rd	1.1	17	75.9	A	3.0
64	39	E Old Spanish Trail	Camino Seco	Harrison Rd	1.2	19	72.8	C	2.9
65	11	E Roger Road	1st Ave	Campbell Ave	1.0	23	53.3	C	2.9
66	28	E Pima Street	Country Club Rd	Alvernon Way	1.0	24	50.1	C	2.9
67	21	E Glenn Street	Alvernon Way	Swan Rd	1.0	23	51.9	C	2.8
68	88	S Calle Santa Cruz	Drexel Rd	Valencia Rd	1.0	17	63.8	C	2.8
69	66	E Bilby Road	Nogales Hwy	Campbell Ave	1.1	16	71.2	C	2.5
70	43	E Silverlake Road	South Tucson	Cherrybell Strav	1.0	13	79.6	C	2.5
71	122	N Columbus Boulevard	Grant Rd	Speedway Bld	1.0	20	51.4	C	2.5
72	92	N Fairview Avenue	Miracle Mile	Grant Rd	0.8	15	50.2	C	2.2
73	124	S Columbus Boulevard	Broadway Bld	22nd St	1.0	15	58.2	C	2.1
74	45	E 36th Street	South Tucson	Campbell Ave	0.9	15	52.3	A	2.0
75	20	E Glenn Street	Country Club Rd	Alvernon Way	1.0	11	75.0	C	2.0
76	22	E Glenn Street	Swan Rd	Craycroft Rd	1.0	10	80.8	C	1.9
77	117	S Country Club Road	Irvington Rd	Drexel Rd	1.1	16	51.6	A	1.9
78	87	S Calle Santa Cruz	Irvington Rd	Drexel Rd	1.0	9	80.6	C	1.9
79	27	E Elm Street	Campbell Ave	Country Club Rd	1.0	9	82.8	C	1.8
80	115	S Country Club Road	36th St	Ajo Way	0.9	11	56.4	A	1.7
81	127	N Rosemont Boulevard	Grant Rd	Speedway Bld	1.0	9	69.2	C	1.5
82	83	S Oak Tree Drive	Midvale Park Rd	Valencia Rd	1.8	14	74.0	C	1.5
83	137	S Camino Seco	Escalante Rd	Irvington Rd	1.0	11	55.8	C	1.5
84	133	S Prudence Road	22nd St	Golf Links Rd	1.0	10	60.4	C	1.4
85	100	N Park Avenue	Fort Lowell Rd	Grant Rd	1.0	10	55.8	C	1.4
86	118	S Country Club Road	Drexel Rd	Valencia Rd	1.0	11	51.0	A	1.4
87	31	W University Boulevard	Main Ave	6th Ave	0.5	3	85.0	C	1.2
88	134	S Prudence Road	Golf Links Rd	Escalante Rd	1.0	6	82.8	C	1.2

Street Classes:

A = Arterial

C = Collector

Exhibit 10 (continued)
RESULTS OF PRIORITY RANKING ANALYSIS (Warranty Score > 50)

Rank	Seg	On Street	From Street	To Street	Length (miles)	Night ADT (100's)	Warranting Score	Street Class	Priority Score
89	48	E Stella Road	Kolb Rd	Pantano Rd	1.0	7	63.4	C	1.1
90	120	N Alvernon Way	Kleindale	Fort Lowell Rd	0.7	3	92.4	A	0.9
91	44	Fairland Strav	Cherrybell Strav	Country Club Dr	1.3	5	86.9	C	0.9
92	54	E Escalante Road	Camino Seco	Pantano Creek	0.6	2	69.2	A	0.6
93	86	S Valley Road	Ajo Way	Irvington Rd	1.0	4	54.0	C	0.6
94	142	Prudence Road	Broadway Bld	22nd St	1.0	1.7	76.2	C	0.3

Street Classes:

A = Arterial
C = Collector

5. RECOMMENDED PROGRAM

The recommended street lighting improvement program is presented in this chapter. Specific improvement projects are summarized for each of the next ten years.

ANALYTICAL BASE

The analytical basis for the candidate improvement process was the priority ranking analysis described in Chapter 4. These ratings were derived systematically by comparing the nighttime visual requirements at the various locations and by determining the relative effectiveness potential. As stated in Chapter 4, high-ranking segments generally indicate complex nighttime traffic operating conditions, nighttime accident problems, and generally relatively high nighttime traffic volumes.

CAPITAL IMPROVEMENT PROGRAM

The proposed roadway lighting capital improvement program (CIP) has been developed to span a 10-year frame. Over that period, lighting improvements are to be constructed to complete the recommended roadway lighting on Tucson's major arterial street system. Also, lighting will be constructed on a number of collector streets. As stated above, the basis of the program was the warranting analysis and priority ranking procedures described in Chapter 4. This provides a systematic process by which the limited funds available may be most effectively applied.

The total cost of the proposed program is \$36.7 million. This is expressed in Year 2002 dollars without any additional escalation factors applied. This money will construct lighting improvements on 84 miles of roadways. The capital improvement program is presented in Exhibit 11 in a tabular form, including definitions of the roadway segment, street classification, length, cost, and cumulative cost and length. Exhibit 12 illustrates the projects for Years 1 through 5 and Years 6 through 10 projects.

Unit costs for the projects were developed for different roadway types utilizing current City of Tucson design standards, and representative component unit costs provided by the City of Tucson. Assumptions include 400-watt high-pressure sodium luminaires mounted at a height of 35 feet with 15-foot mast arms and setbacks of 9 feet. A staggered pole arrangement was also assumed for this analysis.

Exhibit 11
RECOMMENDED 10-YEAR CAPITAL IMPROVEMENT PROGRAM

Project No.	Seg	On Street	From Street	To Street	Length (miles)	Street Class	Fiscal Year (Cost, \$1,000s)					Cum. Cost Total (\$1,000s)	Cum. Total Miles
							1	2	3	4	5		
1	69	W Valencia Road	City Limits	Oak Tree Dr	0.5	A	\$239					\$239	0.5
2	93	N 6th Avenue	Drachman St	Speedway Blvd	0.2	A	\$91					\$330	0.7
3	55	E Irvington Road	6th Ave	Park Ave	0.7	A	\$323					\$654	1.4
4	106	E Benson Highway	Treat Ave	Country Club Rd	0.3	A	\$132					\$786	1.7
5	132	N Sabino Canyon Road	City Limits	Fanque Verde Rd	0.9	A	\$430					\$1,216	2.6
6	110	N Country Club Road	Prince Rd	Fort Lowell Rd	0.5	A	\$228					\$1,444	3.1
7	24	Wrightstown Rd	Tanque Verde Rd	Wrightstown Terrace	0.6	A	\$254					\$1,698	3.7
8	80	S Mission Road	Congress St	22nd St	1.1	A	\$466					\$2,165	4.8
9	38	E Old Spanish Trail	Broadway Blvd	Camino Seco	0.5	C	\$211					\$2,375	5.3
10	6	W Wetmore Road	Fairview Ave	Oracle Rd	0.5	A	\$228					\$2,603	5.8
11	131	S Calle Polar	Nicaragua Dr	Escalante Rd	0.3	C	\$126					\$2,729	6.1
12	50	E Nicaragua Dr	Wilnot Rd	Calle Polar	0.3	C	\$126					\$2,856	6.4
13	79	N Silverbell Road	St Mary's Rd	Congress St	0.8	A	\$365					\$3,221	7.2
14	13	W Fort Lowell Road	Oracle Rd	1st Ave	1.0	A	\$462					\$3,683	8.2
15	82	S Mission Road	Irvington Rd	Drexel Rd	0.9	A	\$433					\$4,115	9.1
16	96	S 6th Avenue	Irvington Rd	Drexel Rd	1.0	C	\$421					\$4,536	10.1
17	4	E River Road	Dodge Bld	River Oak Tr	0.9	A	\$410					\$4,947	11.0
18	41	E 22nd Street	6th Ave	Kino Pkwy	1.1	A	\$561					\$5,508	12.1
19	37	E Broadway Boulevard	Camino Seco	Harrison Rd	1.0	A	\$428					\$5,936	13.1
20	16	E Fort Lowell Road	Columbus Blvd	Swan Rd	0.6	A	\$277					\$6,213	13.7
21	25	E Wrightstown Road	Tanque Verde Rd	Canine Seco Rd	0.8	A	\$339					\$6,552	14.5
22	98	S Nogales Highway	6th Ave	Drexel Rd	1.0	A	\$434					\$6,986	15.5
23	42	E 22nd Street	Canino Seco	Harrison Rd	1.0	A	\$428					\$7,414	16.5
24	99	S Nogales Highway	Drexel Rd	Valencia Rd	1.0	A	\$434					\$7,848	17.5
25	84	S Midvale Park Road	Irvington Rd	Drexel Rd	0.9	A	\$396					\$8,244	18.4
26	81	S Mission Road	Ajo Way	Irvington Rd	1.3	A	\$625					\$8,870	19.7
27	12	E Prince Road	Campbell Ave	Country Club Rd	1.0	A	\$456					\$9,326	20.7
28	60	W Drexel Road	Mission Rd	Santa Cruz River	1.1	C	\$484					\$9,810	21.8
29	32	E 5th Street	Country Club Rd	Alvernon Way	1.0	C	\$440					\$10,250	22.8
30	123	N Columbus Boulevard	Speedway Blvd	5th St	0.5	C	\$220					\$10,470	23.3
31	125	S Columbus Boulevard	22nd St	29th St	0.5	C	\$220					\$10,690	23.8
32	5	W El Camino Del Cetro	Silverbell Rd	1-10	0.8	A	\$339					\$11,029	24.6
33	52	E Escalante Road	Calle Polar	Kobl Rd	0.8	A	\$339					\$11,368	25.4
34	30	E Speedway Boulevard	Canino Seco	Harrison	1.0	A	\$424					\$11,792	26.4
35	75	N Silverbell Road	City Limits	El Camino Del Cetro	0.8	A	\$339					\$12,131	27.2
36	46	E 36th Street	Country Club Rd	City Limits	0.5	A	\$228					\$12,359	27.7
37	61	W Drexel Road	1-19	12th Ave	0.5	C	\$220					\$12,579	28.2
38	138	N Harrison Road	Wrightstown Rd	Speedway Blvd	0.5	A	\$212					\$12,791	28.7

RECOMMENDED 10-YEAR CAPITAL IMPROVEMENT PROGRAM

Exhibit 11 (continued)

Project No.	Seg	On Street	From Street	To Street	Length (miles)	Street Class	Fiscal Year (Cost, \$1,000s)					Cum. Cost (\$1,000s)	Cum. Total Miles	
							1	2	3	4	5			
39	19	E Glenn Street	Tucson Blvd	Country Club Rd	0.5	C	\$220						\$13,011	29.2
40	101	N Park Avenue	Grant Rd	Speedway Blvd	1.0	C	\$421						\$13,432	30.2
41	29	E Pima Street	Alvernon Way	Swan Rd	1.0	C	\$440						\$13,872	31.2
42	76	N Silverbell Road	El Camino Del Cielo	Sweetwater	1.1	A	\$466						\$14,339	32.3
43	59	E Irvington Road	Camino Seco	Harrison Rd	1.0	A	\$424						\$14,763	33.3
44	17	W Glenn St	Flowing Wells Rd	Fairview Ave	0.4	C	\$176						\$14,939	33.7
45	62	E Drexel Road	12th Ave	Nogales Hwy	0.9	C	\$396						\$15,335	34.6
46	130	N Wilmett Road	Grant Rd	Pima St	0.5	C	\$220						\$15,555	35.1
47	57	E Irvington Road	Koib Rd	Pantano Rd	1.0	A	\$424						\$15,979	36.1
48	78	N Silverbell Road	Goret Rd	Grant Rd	0.9	A	\$382						\$16,360	37.0
49	136	S Camino Seco	Golf Links Rd	Escalante Rd	1.1	C	\$384						\$16,844	38.1
50	139	S Harrison Road	Golf Links Rd	Escalante Rd	1.0	A	\$424						\$17,268	39.1
51	26	E Wrightstown Road	Camino Seco	Harrison	1.0	A	\$456						\$17,724	40.1
52	72	E Valencia Road	Koib Rd	Old Vail Rd	2.3	A	\$975						\$18,699	42.4
53	135	S Sarnoff Drive	22nd St	Pantano Pkwy	0.5	C	\$220						\$18,919	42.9
54	105	E Benson Highway	Park Ave	Kino Pkwy	1.1	A	\$526						\$19,445	44.0
55	114	S Country Club Road	22nd St	Aviation Hwy	0.6	A	\$274						\$19,719	44.6
56	10	W Roger Road	Flowing Wells Rd	Oracle Rd	1.0	C	\$440						\$20,159	45.6
57	77	N Silverbell Road	Sweetwater Dr	Goret Rd	1.4	A	\$594						\$20,752	47.0
58	64	E Drexel Road	Campbell Ave	Country Club Rd	1.0	A	\$456						\$21,208	48.0
59	107	N Tucson Boulevard	Prince Rd	Fort Lowell Rd	0.5	C	\$220						\$21,428	48.5
60	103	E Cherrybell Strat	22nd St	Silverlake Rd	0.5	C	\$211						\$21,639	49.0
61	140	S Harrison Road	Escalante Rd	Irvington Rd	1.0	A	\$424						\$22,063	50.0
62	97	S 6th Avenue	Drexel Rd	Valencia Rd	1.0	C	\$421						\$22,484	51.0
63	116	S Country Club Road	Ajo Way	Irvington Rd	1.1	A	\$466						\$22,950	52.1
64	39	E Old Spanish Trail	Camino Seco	Harrison Rd	1.2	C	\$505						\$23,455	53.3
65	11	E Roger Road	1st Ave	Campbell Ave	1.0	C	\$440						\$23,895	54.3
66	28	E Pima Street	Country Club Rd	Alvernon Way	1.0	C	\$440						\$24,335	55.3
67	21	E Glenn Street	Alvernon Way	Swan Rd	1.0	C	\$440						\$24,775	56.3
68	88	S Calle Santa Cruz	Drexel Rd	Valencia Rd	1.0	C	\$421						\$25,196	57.3
69	66	E Bilby Road	Nogales Hwy	Campbell Ave	1.1	C	\$484						\$25,680	58.4
70	43	E Silverbell Road	South Tucson	Cherrybell Strat	1.0	C	\$440						\$26,120	59.4
71	122	N Columbus Boulevard	Grant Rd	Speedway Blvd	1.0	C	\$440						\$26,560	60.4
72	92	N Fairview Avenue	Miracle Mile	Grant Rd	0.8	C	\$353						\$26,912	61.2
73	124	S Columbus Boulevard	Broadway Blvd	22nd St	1.0	C	\$440						\$27,352	62.2
74	45	E 16th Street	South Tucson	Campbell Ave	0.9	A	\$410						\$27,763	63.1
75	20	E Glenn Street	Alvernon Way	1.0	C	\$440							\$28,203	64.1
76	22	E Glenn Street	Country Club Rd	Swan Rd	1.0	C	\$440						\$28,643	65.1

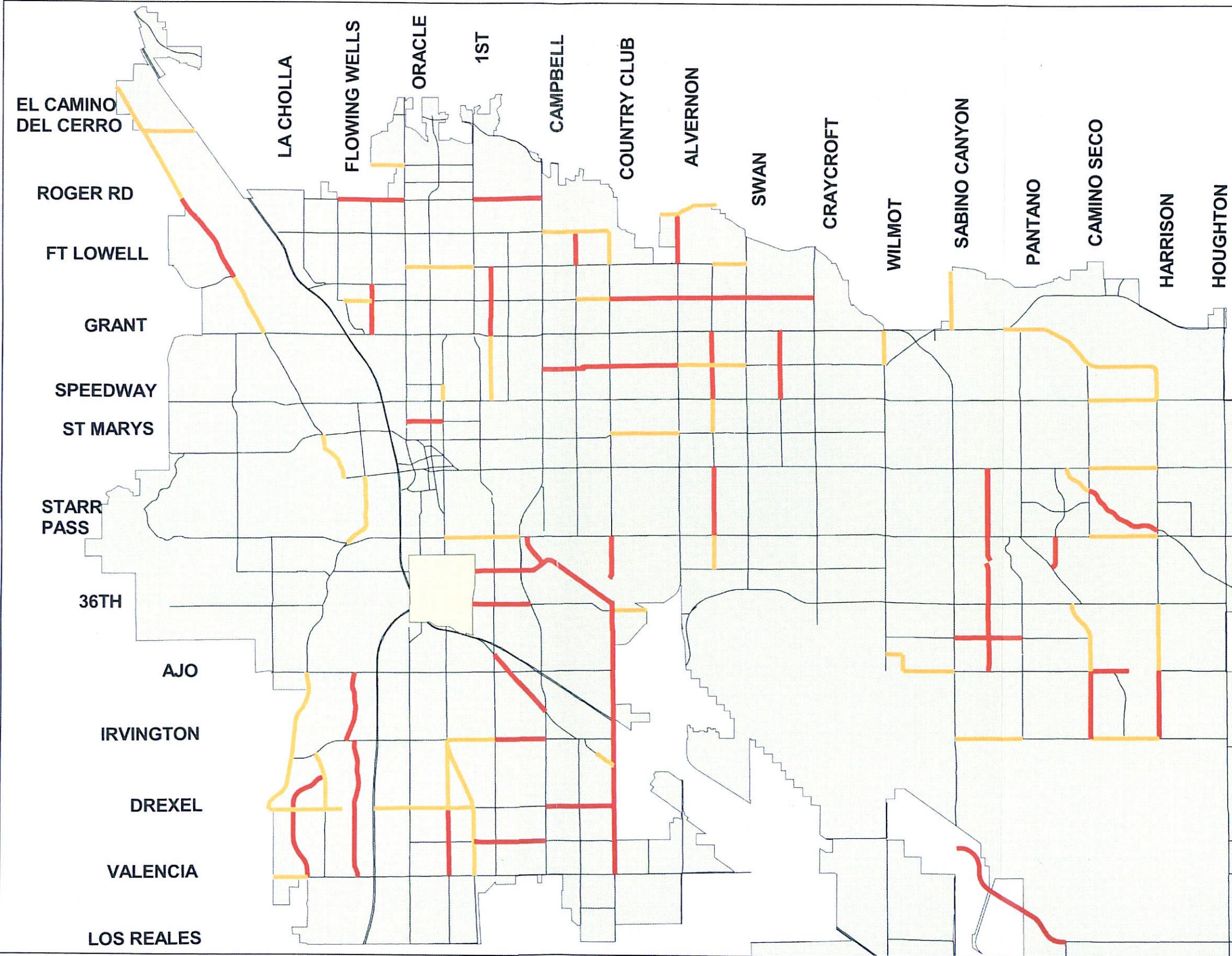
Exhibit 11 (continued)

RECOMMENDED 10-YEAR CAPITAL IMPROVEMENT PROGRAM

Project No.	Seg	On Street	From Street	To Street	Length (miles)	Street Class	Fiscal Year (Cost, \$1,000s)					Cum. Cost (\$1,000s)	Cum. Total Miles
							1	2	3	4	5		
77	117	S Country Club Road	Irvington Rd	Drexel Rd	1.1	A						\$466	\$29,109
78	87	S Calle Santa Cruz	Irvington Rd	Drexel Rd	1.0	C						\$421	\$29,530
79	27	E Elm Street	Campbell Ave	Country Club Rd	1.0	C						\$440	\$29,970
80	115	S Country Club Road	36th St	Ajo Way	0.9	A						\$382	
81	127	N Rosemont Boulevard	Grant Rd	Speedway Blvd	1.0	C						\$440	\$30,352
82	83	S Oak Tree Drive	Midvale Park Rd	Valencia Rd	1.8	C						\$758	\$30,792
83	137	S Canino Seco	Escalante Rd	Irvington Rd	1.0	C						\$440	\$31,550
84	133	S Prudence Road	22nd St	Golf Links Rd	1.0	C						\$440	\$31,990
85	100	N Park Avenue	Fort Lowell Rd	Grant Rd	1.0	C						\$421	\$32,430
86	118	S Country Club Road	Drexel Rd	Valencia Rd	1.0	A						\$424	\$32,851
87	31	W University Boulevard	Main Ave	6th Ave	0.5	C						\$220	\$33,275
88	134	S Prudence Road	Golf Links Rd	Escalante Rd	1.0	C						\$440	\$33,495
89	48	E Stella Road	Kolb Rd	Panlano Rd	1.0	C						\$440	\$33,935
90	120	N Alvernon Way	Kleindale	Fort Lowell Rd	0.7	A						\$319	\$34,375
91	44	Fairland Strav	Cherrybell Strav	Country Club Dr	1.3	C						\$547	\$34,694
92	54	E Escalante Road	Canino Seco	Pantano Creek	0.6	A						\$547	\$35,241
93	86	S Valley Road	Ajo Way	Irvington Rd	1.0	C						\$254	\$35,496
94	142	Prudence Road	Broadway Blvd	22nd St	1.0	C						\$421	\$35,917
95*	56	E Irvington Road	Park Ave	Campbell Ave	0.8	A						\$347	\$36,338
ANNUAL TOTALS:							\$3,683	\$3,304	\$3,703	\$3,649	\$3,386	\$3,704	\$3,768
													\$4,254

* Irvington Road, Park Avenue to Campbell segment was added, based on discussions with COT staff, to maintain continuity of lighted roadway on Irvington Road between Mission Road and I-10.

LEGEND	
	- Year 1-5 Projects
	- Year 6-10 Projects
	- City of Tucson
	- City of South Tucson
	- Major Streets



In addition to the assumptions described above, a “spacing matrix” of lighting system costs was developed based on the classification of roadway considered in the City of Tucson standards. For the purposes of this project the roadways analyzed were either classified as major arterials or collectors. Each roadway segment was then sub-classified by the type of area the roadway passes through: Commercial, Urban Intermediate, or Residential. In general, the Commercial classification describes an area in which there may be a high pedestrian usage as well as heavy demand for parking spaces nearby. The Residential classification describes an area that is characterized by few pedestrians and parking areas. The Urban Intermediate classification describes areas that experience moderate pedestrian traffic and parking usage. Luminaire spacing is generally closer in more commercial settings and with wider roadways. Exhibit 13 shows the approximate cost per mile based on roadway type, width, and area classification.

The recommendations contained in this document are based on the analytical computations of the priority ranking analysis. Ranking of projects has not been adjusted to coincide with the other proposed city projects that may overlap with these improvements. In particular, certain planned roadway improvement projects most likely include roadway segments for this program, and may include provision of lighting improvements. For that reason, the total cost presented here may in part be covered elsewhere in the city program. Also, the costs presented for proposed projects on collector roadways do not include potential participation of local improvement districts.

Exhibit 13
LIGHT POLE SPACING/COST MATRIX

Spacing (ft) of Light Poles

	Major				Collector	
	Commercial	Urban Intermediate	Residential	Commercial	Urban Intermediate	Residential
Case 1	2-lane or 3-lane, 48' to 52' curb to curb	130	170	250	200	200
Case 2	4-lane, 54' curb to curb	120	170	240	195	200
Case 3	4-lane divided, 78' curb to curb	95	140	200	130	130
Case 4	5-lane, 64' curb to curb	110	160	220	185	185
Case 5	6-lane divided, 100' curb to curb	70	90	135	90	90

Cost per Mile (\$1000s)

	Major				Collector	
	Commercial	Urban Intermediate	Residential	Commercial	Urban Intermediate	Residential
Case 1	2-lane or 3-lane, 48' to 52' curb to curb	\$488	\$456	\$424	\$440	\$440
Case 2	4-lane, 54' curb to curb	\$497	\$456	\$428	\$443	\$440
Case 3	4-lane divided, 78' curb to curb	\$535	\$478	\$440	\$488	\$488
Case 4	5-lane, 64' curb to curb	\$510	\$462	\$434	\$450	\$450
Case 5	6-lane divided, 100' curb to curb	\$595	\$544	\$481	\$544	\$544

Annualized Cost per Mile

	Major				Collector	
	Commercial	Urban Intermediate	Residential	Commercial	Urban Intermediate	Residential
Case 1	2-lane or 3-lane, 48' to 52' curb to curb	\$48,835	\$44,219	\$39,603	\$41,911	\$41,911
Case 2	4-lane, 54' curb to curb	\$50,219	\$44,219	\$40,065	\$42,373	\$41,911
Case 3	4-lane divided, 78' curb to curb	\$55,758	\$47,450	\$41,911	\$48,835	\$39,142
Case 4	5-lane, 64' curb to curb	\$52,066	\$45,142	\$40,988	\$43,296	\$39,142
Case 5	6-lane divided, 100' curb to curb	\$64,528	\$57,143	\$47,912	\$57,143	\$47,912

6. ADDITIONAL STUDIES

In addition to the specific priority analysis conducted as part of this study, other issues relating to roadway lighting within the City of Tucson were also studied. A review of existing lighting systems was conducted by measuring lighting levels along eighteen segments within the City of Tucson. A technical evaluation of luminaire mounting heights was also conducted at the request of the City of Tucson Department of Transportation. This assessment was requested in order to determine if installing luminaires at a 40-foot height instead of the current practice of 35-foot mounting height significantly improves nighttime lighting levels. Implementing this change would require the City of Tucson to purchase additional vehicles (bucket trucks) with equipment facilities that could reach the bulbs mounted at 40-foot height for periodic maintenance.

REVIEW OF EXISTING LIGHTING SYSTEM AND NIGHTTIME READINGS

The City of Tucson selected eighteen distinct segments of existing roadway lighting for review of equipment and nighttime light level readings. The list of roadway segments was developed from the city's records for roadway lighting systems installed between the years 1950 to 1983. The majority of systems identified on the list represent systems installed between 1967 to 1983. Several of the selected segments have been upgraded to use luminaires manufactured during the 1990's, hence incorporating new technologies for light distribution.

Each roadway segment was field inventoried to determine pole cycles (spacing of poles) that are representative of the individual selected roadway segment. On several segments, more than one (1) pole cycle was identified for the existing lighting conditions.

For each finite segment of roadway selected for review, a nighttime survey was conducted to read and record the existing lighting levels. Each survey was conducted during the nighttime hours of 10:00 PM to 4:00 AM so as to reduce the effect of vehicular lights to a minimum (no readings were taken while vehicles passed through the survey area). Weather was not an adverse or advantage factor, as the nighttime weather was clear and dry without any moonlight contribution.

The survey method used was that recommended by the Illuminating Engineering Society of North America (IESNA). In general, the method requires the sample roadway to represent

one (1) full pole spacing cycle that is representative of the spacing utilized for the entire roadway segment. Additionally, a 10-foot by 10-foot grid was laid out for location points of readings. A reading was recorded at the curb line, center of the bike lane (where it existed), center of the first travel lane, center of the next travel lane, etc., until the far side curb reading was read and recorded.

Exhibit 14 includes the results of the field review. Data identified include the field facilities used for the lighting system, the calculated values of average foot-candle, minimum foot-candle, and uniformity ratio using the IESNA method. Where the IESNA method was not calculated the “pole to pole” method results are indicated. The “pole to pole” method is currently used by the City of Tucson to review field lighting levels for maintenance purposes. However, for the purposes of this study the industry standard IESNA method, was applied.

For roadways within commercial or intermediate areas, the City of Tucson Uniformity Ratio standard is 3:1. The results of this analysis indicate that most of the segments measured do not meet the City of Tucson standard for Uniformity Ratio (minimum/average maintained horizontal illumination, measured in foot-candles).

However, the average maintained horizontal illumination is considered to be a better indicator of consistent lighting condition as one “dark spot” can skew the results of the Uniformity Ratio to the detriment of the measured area. The City of Tucson standard for average maintained horizontal illumination is 1.4 foot-candles for major roadways and 0.9 foot-candles for collectors with areas designated as “urban intermediate”. Most of the measured segments were within the acceptable standards for average maintained horizontal illumination.

It should be noted that although eight of the lit segments did not meet the City standard for average maintained horizontal illumination, this may not be due to improper light spacing. Measured segments may have been in need of maintenance at the time of the field review, thus resulting in measurements that were recorded as substandard. It is recommended that the City review maintenance records for these locations, and field check these locations for missing bulbs or other reasons for insufficient lighting. The City should make the final determination on a priority listing for lighted segments if reasons other than maintenance issues indicate a need for additional lighting improvements at these locations.

Exhibit 14

SELECTED LIGHTED STREET SEGMENTS - FIELD RESULTS

No.	Street Name	From Street	To Street	Date Built	Length (Miles)	Wattage	Average Spacing (Feet)	Typical Spacing (Feet)	Pole Placement	City No.	Height	Type	Cutoff	Mast Arm Length	Foot-Candle	Min. to Average Foot-Candle Ratio	
1a	22nd Street	Craycroft Road	Wilmett Road	May-67	1	400/250	120	2.5	Staggered	F-63-04	25'-30'	Cobra	Semi w/Chinese Cap	5 ft.	2,463	0.10	24,628
1b	22nd Street	Craycroft Road	Wilmett Road	May-67	1	400	120	2	Staggered	F-63-04	30'	Cobra	Semi w/Chinese Cap	8 ft.	0.586	0.20	2,928
1c	22nd Street	Wilmett Road	Kuhl Road	May-67	1	400	120	2.5	Staggered	F-63-04	25'	Cobra	Semi w/Chinese Cap	8 ft.	0.317	0.40	0.792
2	6th Street	Church Avenue	Stone Avenue	Pre-1983	0.2	Various (100, 250, 400)		2.5	Sporadically		30'-35'	Cobra	Semi	8 ft.	1,386	0.15	13,856
3	6th Street	Tucson Blvd	Country Club Road	Jan-82	0.5	400	150	12	Staggered	F-72-01	35'	Chinese Cap	Semi	15 ft.	3,283	0.75	5,66
4	Alvernon Way	Broadway Blvd	22nd Street	Dec-73	1	250	80	2.5	Staggered	F-72-02	35'	Chinese Cap	Semi	5 ft.	2,044	0.98	2,085
5a	Broadway Blvd	Country Club Road	Columbus Blvd	Apr-74	1.5	400	80	2.5	Staggered	F-72-02	35'	Chinese Cap	Semi	5 ft.	2,409	0.56	4,301
5b	Broadway Blvd	Country Club Road	Columbus Blvd	Apr-74	1.5	400	80	2.5	Staggered	F-72-02	35'	Chinese Cap	Semi	5 ft.	1,723	0.10	17,229
6	Campbell Avenue	Leister Street	2nd Street	Jun-79	0.6	150/250	100	2.5	Staggered	I-77-07	25'-30'	Cobra	Full	8 ft.	2,092	0.72	2,905
7	Campbell Avenue	2nd Street	6th Street	Apr-82	0.4	400	75	2	Staggered		30'	Cobra	Full	8 ft.	1,649	0.54	3,054
8a	Church Avenue	Council Street	Franklin Street	Pre-1983	0.2	50	100	4.5	Staggered		16'	Post Top	Non-Cutoff	N.A.	0.193	0.05	3,859
8b	Church Avenue	Alameda Street	Council Street	Pre-1983	0.1	150	75	2	Staggered		30'	G, CBD	Full	8 ft. (G), N/A (CBD)	2,673	0.55	4,859
8c	Church Avenue	Alameda Street	Pima County Couis	Pre-1983	0.1	150	50	1.3	Staggered		30'	CBD	Full	N/A.	3.96	0.25	15,839
8d	Church Avenue	Congress Street	Pennington Street	Pre-1983	0.1	150	35	2	Staggered		30'	Cobra	Full	8 ft.	2,039	1.45	1,406
9	Congress Street	Silverbell Road	Grande Avenue	May-69	0.3	250	200	2	Staggered	F-68-01	30'	Cobra	Full	9 ft.	1,114	0.05	11,136
10	Glenn Street	Campbell Avenue	Tucson Boulevard	Pre-1983	0.5	150	Varies	2	Staggered		30'	Cobra	Full	8 ft.	0.335	0.01	33,453
11a	Grande Avenue	Speedway Blvd	Saint Mary's Road	Jul-79	0.4	400	150	2.5	Staggered	F-78-002	30'	Cobra	Full	8 ft.	4,097	0.50	8,195
11b	Grande Avenue	Speedway Blvd	Saint Mary's Road	Jul-79	0.4	400	150	2.5	Staggered	F-78-002	30'	Cobra	Full	8 ft.	1,926	0.15	12,839
12	Grande Avenue	Franklin Street	Congress	May-69	0.3	250	180	2.5	Staggered	F-68-01	30'	Cobra	Full	8 ft.	1,631	0.05	32,614
13a	Kino Parkway	Valencia Road	Valencia Road	Pre-1983	2.4	400	115	11	Staggered	I-81-59	40'	2E	Full	N/A	2,591	0.78	3,321
13b	Kino Parkway	Valencia Road	Valencia Road	Pre-1983	2.4	400	115	11	Staggered	I-81-59	40'	2E	Full	N/A	2,627	0.62	4,237
14a	Miracle Mile	Oracle Road	1-10	Pre-1983	1.5	250	100	8	Median	I-89-01	30'	Dbl. Arm	Cobra-Jull	20 ft.	2,812	1.20	2,343
14b	Miracle Mile	Oracle Road	1-10	Pre-1983	1.5	250	100	8	Median	I-89-01	30'	Dbl. Arm	Cobra-Jull	20 ft.	2,332	1.00	2,332
15	Saint Mary's Road	Granada Avenue	Granada Avenue	Nov-63	0.3	400	150	9	Staggered	F-63-3	30'	Cobra	Full	8 ft.	1,835	0.20	9,277
16	Speedway Blvd	Main Avenue	Apr-64	0.3	400	110			Staggered	I-65-41	30'	Cobra	Full	7 ft.	1,232	0.15	8,217
17	Stone Avenue	6th Street	Brachman Street	Jan-50	0.7	250/400	180	2	Staggered	I-71	30'	Cobra	Full	8 ft.	3,018	0.45	6,706
18	Tucson Blvd	Broadway Blvd	Speedway Blvd	Pre-1983	1	250	230	2.5	Sporadically		35'	Cobra	Full	8 ft.	0,628	0.01	62,774

Both Pole to Pole method (COT) andIESNA methods were calculated. IESNA results (unless otherwise noted) are shown in this Exhibit.

COMPARISON OF MOUNTING HEIGHTS

A second study was conducted to compare spacing and lighting levels with luminaires mounted at heights of 35 feet and 40 feet. Lighting calculations were prepared for various roadway configurations and for various roadway lighting systems. A common factor of all calculations was the use of a luminaire with a 400-watt high-pressure sodium lamp enclosed in a full cutoff housing. For each roadway configuration two (2) luminaire mounting heights were separately included (35-foot and 40-foot) in the sets of calculations. Lighting calculations were prepared for the following roadway configurations:

1. Two (2) travel lanes plus a bike lane.
 - a. Lighting system poles to be staggered.
 - b. Lighting system poles to be single sided.
2. Two (2) travel lanes, plus a turn lane, plus a bike lane.
 - a. Lighting system poles to be staggered.
 - b. Lighting system poles to be single sided.
3. Four (4) travel lanes; plus a turn lane, plus a bike lane.
 - a. Lighting system poles to be staggered.
4. Four (4) travel lanes; plus a 20-foot median, plus a bike lane.
 - a. Lighting system poles to be staggered.
5. Four (4) travel lanes; plus a 24-foot median, plus a bike lane.
 - a. Lighting system poles to be staggered.
6. Four (4) travel lanes; plus a 20-foot median, plus a bike lane.
 - a. Lighting system poles to be installed as a staggered system, but the lighting calculation to be representative of a single sided pole system.
7. Four (4) travel lanes; plus a 24-foot median, plus a bike lane.
 - a. Lighting system poles to be installed as a staggered system, but the lighting calculation to be representative of a single sided pole system.

The lighting results of the lighting calculations of each of the configurations follow this section. In general, when the lighting criteria is to meet the average maintained horizontal illumination standard level of 1.4 foot-candles with the uniformity ratio (average to minimum foot-candle level) being between 3:1 to 4:1, either pole can be used as the pole spacing is fairly close. When the lighting criteria is to achieve a uniformity ratio close to 3:1, the use of the 40-foot pole results in an improved spacing over the 35-foot pole. The 40-foot pole arrangement

also indicates that the average maintained foot-candle level of 1.4 foot-candles is more closely met than not. The analysis results shown in Exhibit 15 show the spacing required to achieve both average maintained horizontal foot-candle level of 1.4 foot-candles and the average to minimum uniformity ratio of 3:1, based on City of Tucson standards.

This analysis of light pole spacing is based on an even spacing of poles throughout a lighting system; however, in reality, poles are located based on lighting studies specific to the roadway studied, and are subject to placement modifications because of obstacles such as existing driveways, utilities, and the location of cross streets.

Exhibit 15
**COMPARISON OF LIGHT SPACING FOR 35' AND 40' LUMINAIRE MOUNTING
 HEIGHTS**

	35' Mounting Height		40' Mounting Height	
	Staggered	Single Sided	Staggered	Single Sided
Two lanes plus bike lanes	170'	160'	185'	180'
Two lanes, plus a TWLTL, plus bike lanes	180'	170'	180'	170'
Four lanes, plus a TWLTL, plus bike lanes	110'	N/A	135'	N/A
Four lanes, plus a 20 ft median, plus bike lanes	90'	N/A	125'	N/A
Four lanes, plus a 24 ft median, plus bike lanes	90'	N/A	125'	N/A
Four lanes, plus a 20 ft. median, plus bike lanes*	160'	N/A	180'	N/A
Four lanes, plus a 24 ft. median, plus bike lanes*	160'	N/A	180'	N/A

* Lighting system poles installed as staggered system, but lighting calculation representative of single sided pole system.

Note: Based on Illuminating Engineering Society of North America standard of 1.4 Average Foot-Candle and 3:1 (COT) Ave/Min Uniformity Ratio standard.

APPENDIX A

Accident Data

Segment	On Street	From Street	To Street	Distance (miles)	Volumes (x100)			Night Rate	Day Rate	Total Rate	Ratio NT / DY	Night Accident Freq	Day Accident Freq	Total Accident Freq	Ratio NT / DY	Fixed Object Acc	Night Ped Acc	Collision Maneuvers			
					Night	Day	Total											Angle	Left Turn	Rear End	Head On
1	River Rd	Thornydale Rd	Shannon Rd	1.3	57	133	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0
2	River Rd	Oracle Rd	First Ave	1.0	113	272	0.89	1.21	1.11	0.74	3.67	12.00	15.67	0.31	4	1	5	1	15	0	0
3	River Rd	First Ave	Campbell Ave	1.2	93	217	1.23	1.51	1.15	0.81	4.17	8.89	13.06	0.47	6	3	5	6	31	0	0
4	River Rd	Dodge Blvd	River Oak Tr	0.9	47	117	0.22	0.17	0.19	1.24	0.37	0.74	1.11	0.50	1	0	1	0	1	0	0
5	El Camino Del Cerro	Silverbell Rd	I-10	0.8	39	91	0.29	0.75	0.61	0.39	0.42	2.50	2.92	0.17	1	0	0	1	3	0	0
6	Wetmore Rd	Fairview Ave	Oracle Rd	0.5	46	122	1.99	3.14	2.83	0.63	3.33	14.00	17.33	0.24	1	0	9	9	5	0	0
7	Wetmore Rd	Oracle Rd	First Ave	1.0	62	137	2.21	2.00	2.07	1.10	5.00	10.00	15.00	0.50	0	0	8	7	3	0	0
8	Limberlost Dr	Oracle Rd	First Ave	1.0	14	42	1.96	2.61	2.45	0.75	1.00	4.00	5.00	0.25	1	1	3	1	1	0	0
9	Roger Rd	Romero Rd	Flowing Wells Rd	0.6	22	53	1.38	1.72	1.62	0.80	1.11	3.33	4.44	0.33	2	1	4	0	2	0	0
10	Roger Rd	Flowing Wells Rd	Oracle Rd	1.0	27	69	2.37	4.24	3.71	0.56	2.33	10.67	13.00	0.22	2	1	10	6	15	1	1
11	Roger Road	First Ave	Campbell Ave	1.0	23	50	3.18	4.57	4.13	0.70	2.67	8.33	11.00	0.32	1	3	12	2	11	0	0
12	Prince Rd	Campbell Ave	Country Club Rd	1.0	57	141	1.60	1.49	1.52	1.08	3.33	7.67	11.00	0.43	3	2	6	4	13	1	1
13	Ft Lowell Rd	Oracle Rd	First Ave	1.0	100	195	1.92	3.47	2.94	0.55	7.00	24.67	31.67	0.28	4	4	22	9	39	2	2
14	Ft Lowell Rd	First Ave	Campbell Ave	1.0	82	205	2.23	3.83	3.37	0.58	6.67	28.67	35.33	0.23	1	2	30	17	40	1	1
15	Ft Lowell Rd	Campbell Ave	Country Club Rd	1.0	83	205	2.86	3.03	2.98	0.94	8.67	22.67	31.33	0.38	2	3	12	12	57	0	0
16	Ft Lowell Rd	Columbus Blvd	Swan Rd	0.6	39	142	1.56	1.29	0.50	1.21	2.22	1.11	3.33	2.00	3	0	1	3	5	1	1
17	Glenn St	Flowing Wells Rd	Fairview Ave	0.4	10	20	6.85	3.42	12.18	2.00	2.50	10.83	13.33	0.23	2	3	0	1	1	0	0
18	Glenn St	Oracle Rd	Stone Ave	0.4	19	27	4.81	11.84	8.93	0.41	3.33	11.67	15.00	0.29	1	0	12	2	1	0	0
19	Glenn St	Tucson Blvd	Country Club Rd	0.5	18	89	2.03	1.64	1.71	1.24	1.33	5.33	6.67	0.25	1	1	0	0	12	0	0
20	Glenn St	Country Club Rd	Alvernon Way	1.0	11	42	9.13	5.87	6.55	1.56	3.67	9.00	12.67	0.41	3	1	10	2	14	0	0
21	Glenn St	Alvernon Way	Swan Rd	1.0	23	45	1.59	2.03	1.88	0.78	1.33	3.33	4.67	0.40	2	1	3	1	4	0	0
22	Glenn St	Swan Rd	Craycroft Rd	1.0	10	50	1.83	0.73	0.91	2.50	0.67	1.33	2.00	0.50	1	2	1	0	3	0	0
23	Tanque Verde Rd	Tanque Verde Wash	Catalina Hwy	1.2	107	257	0.28	0.44	0.40	0.64	1.11	4.17	5.28	0.27	4	1	3	0	10	0	0
24	Wrightstown Rd	Tanque Verde Rd	Wrightstown Terrace	0.6	33	75	5.07	3.25	3.81	1.56	6.11	8.89	15.00	0.69	6	2	3	4	7	0	0
25	Wrightstown Rd	Tanque Verde Rd	Camino Seco	0.8	32	75	0.71	1.07	0.96	0.67	0.83	2.92	3.75	0.29	6	1	3	1	2	0	0
26	Wrightstown Rd	Camino Seco	Harrison Rd	1.0	22	42	1.66	1.09	1.28	1.53	1.33	1.67	3.00	0.80	0	0	1	0	1	0	0
27	Elm St	Campbell Ave	Country Club Rd	1.0	9	44	2.03	0.42	0.69	4.89	0.67	0.67	1.33	1.00	2	2	1	1	1	0	0
28	Pima St	Country Club Rd	Alvernon Way	1.0	24	63	3.81	4.78	4.51	0.80	3.33	11.00	14.33	0.30	5	2	10	2	18	0	0
29	Pima St	Alvernon Way	Swan Rd	1.0	44	118	1.66	3.64	3.10	0.46	2.67	15.67	18.33	0.17	2	1	8	4	35	0	0
30	Speedway Blvd	Camino Seco	Harrison Rd	1.0	47	121	1.75	3.55	2.99	0.49	3.00	15.33	18.33	0.20	1	2	7	3	17	1	1
31	University Blvd	Main Ave	6th Ave	0.5	3	24	30.44	6.09	8.79	5.00	3.33	5.33	8.67	0.63	2	2	4	0	0	0	0
32	5th St	Country Club Rd	Alvernon Way	1.0	46	127	2.38	1.87	2.01	1.27	4.00	8.67	12.67	0.46	4	3	5	19	0	0	0
33	5th St	Alvernon Way	Swan Rd	1.0	51	140	1.25	2.61	2.25	0.48	2.33	13.33	15.67	0.18	3	2	8	2	3	2	0
34	5th St	Swan Rd	Craycroft Rd	1.0	69	85	0.66	5.05	3.14	0.13	1.67	16.00	17.67	0.10	5	1	9	7	23	0	0
35	5th St	Craycroft Rd	Wilmot Rd	1.0	38	126	0.24	4.06	3.17	0.06	0.33	18.67	19.00	0.02	1	0	8	7	24	1	1
36	Broadway Blvd	Pantano Rd	Camino Seco	1.0	114	276	2.00	3.28	2.90	0.61	8.33	33.00	41.33	0.25	6	3	22	22	45	1	1
37	Broadway Blvd	Camino Seco	Harrison Rd	1.0	72	165	2.16	3.04	2.77	0.71	5.67	18.33	24.00	0.31	3	0	9	11	33	0	0
38	Old Spanish Trail	Broadway Blvd	Camino Seco	0.5	25	33	1.46	0.55	0.94	2.64	1.33	0.67	2.00	2.00	0	0	1	2	0	0	0
39	Old Spanish Trail	Camino Seco	Harrison Road	1.2	19	29	1.20	3.94	2.85	0.31	0.83	4.17	5.00	0.20	3	0	10	2	4	0	

Segment	On Street	From Street	To Street	Distance (miles)	Volumes (x100)		Night Rate	Day Rate	Total Rate	Ratio NT / DY	Night Accident Freq	Day Accident Freq	Total Accident Freq	Ratio NT / DY Freq	Fixed Object Acc	Night Ped Acc	Collision Maneuvers			
					Night	Day											Angle	Left Turn	Rear End	Head On
51	Ajo Way	Benson Highway	Kino Pkwy	0.5	59	193	0.93	1.23	1.16	0.75	2.00	8.67	10.67	0.23	0	0	2	1	11	0
52	Escalante Rd	Calle Polar	Kolb Rd	0.8	32	75	1.07	0.76	0.85	1.41	1.25	2.08	3.33	0.60	3	2	1	1	4	0
53	Escalante Rd	Pantano Rd	Camino Seco	1.0	17	32	0.54	4.00	2.80	0.13	0.33	4.67	5.00	0.07	2	1	4	4	3	0
54	Escalante Rd	Camino Seco	Pantano Creek	0.6	2	8	7.61	3.81	4.57	2.00	0.56	1.11	1.67	0.50	0	0	1	0	0	0
55	Irvington Rd	6th Ave	Park Ave	0.7	102	200	3.07	2.54	2.72	1.21	11.43	18.57	30.00	0.62	8	4	7	3	40	2
56	Irvington Rd	Park Ave	Campbell Ave	0.7	103	188	3.04	6.11	5.02	0.50	11.43	41.90	53.33	0.27	2	6	16	20	49	2
57	Irvington Rd	Kolb Rd	Pantano Rd	1.0	31	80	0.59	1.26	1.07	0.47	0.67	3.67	4.33	0.18	3	0	1	2	5	0
58	Irvington Rd	Pantano Rd	Camino Seco	1.0	29	75	0.63	0.97	0.88	0.65	0.67	2.67	3.33	0.25	2	1	1	3	4	0
59	Irvington Rd	Camino Seco	Harrison Rd	1.0	24	60	1.14	0.61	0.76	1.88	1.00	1.33	2.33	0.75	1	0	1	2	2	0
60	Drexel Rd	Mission Rd	Santa Cruz River	1.1	38	62	1.31	0.40	0.75	3.26	1.82	0.91	2.73	2.00	3	2	4	1	0	0
61	Drexel Rd	I-19	12th Ave	0.5	17	29	6.45	2.52	3.97	2.56	4.00	2.67	6.67	1.50	2	2	5	4	3	1
62	Drexel Rd	12th Ave	Nogales Hwy	0.9	26	46	3.90	3.09	3.38	1.26	3.70	5.19	8.89	0.71	4	4	9	1	6	1
63	Drexel Rd	Nogales Hwy	Campbell Ave	1.1	31	56	1.34	2.67	2.19	0.50	1.52	5.45	6.97	0.28	3	3	1	4	12	1
64	Drexel Rd	Campbell Ave	Country Club Rd	1.0	20	46	2.74	1.79	2.08	1.53	2.00	3.00	5.00	0.67	3	0	1	2	8	0
65	Bilby Rd	12th Ave	Nogales Hwy	0.9	16	24	3.17	3.38	3.30	0.94	1.85	2.96	4.81	0.63	4	3	12	1	5	0
66	Bilby Rd	Nogales Hwy	Cambell Ave	1.1	16	37	6.23	3.59	4.39	1.73	3.64	4.85	8.48	0.75	4	1	8	6	9	0
67	Bilby Rd	Campbell Ave	Country Club Rd	1.0	4	9	2.28	4.06	3.51	0.56	0.33	1.33	1.67	0.25	0	0	1	2	1	0
68	Valencia Rd	City Limits	Wilmot Rd	0.9	73	191	0.00	0.11	0.08	0.00	0.00	0.74	0.74	0.00	0	0	1	0	1	0
69	Valencia Rd	City Limits	Oak Tree Dr	0.5	117	259	3.12	1.76	2.19	1.77	13.33	16.67	30.00	0.80	11	5	21	18	17	0
70	Valencia Rd	Oak Tree Dr	I-19	1.0	117	259	3.43	4.97	4.49	0.69	14.67	47.00	61.67	0.31	11	8	12	5	96	2
71	Valencia Rd	Country Club Rd	Alvernon Way	1.5	103	268	0.47	1.05	0.89	0.45	1.78	10.22	12.00	0.17	1	1	6	8	30	0
72	Valencia Rd	Kolb Rd	Old Vail Rd	2.3	42	70	0.38	0.28	0.32	1.33	0.58	0.72	1.30	0.80	7	0	0	0	0	0
73	Valencia Rd	Old Vail Rd	Nexus Dr	0.9	42	70	0.72	1.45	1.18	0.50	1.11	3.70	4.81	0.30	3	0	4	2	1	0
74	Valencia Rd	Nexus Dr	Houghton Rd	1.4	14	35	0.00	0.93	0.67	0.00	0.00	1.19	1.19	0.00	2	0	0	0	2	0
75	Silverbell Rd	City Limits	El Camino Del Cerro	0.8	33	90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0	0	0	0
76	Silverbell Rd	El Camino Del Cerro	Sweetwater Dr	1.1	27	74	0.61	0.22	0.33	2.74	0.61	0.61	1.21	1.00	1	0	1	1	1	0
77	Silverbell Rd	Sweetwater Dr	Goret Rd	1.4	27	74	0.72	0.71	0.71	1.03	0.71	1.90	2.62	0.38	4	0	0	1	1	1
78	Silverbell Rd	Goret Rd	Grant Rd	0.9	27	73	1.50	2.92	2.54	0.51	1.48	7.78	9.26	0.19	4	0	8	4	4	0
79	Silverbell Rd	St Marys Rd	Congress St	0.8	39	174	1.17	0.39	0.54	2.97	1.67	2.50	4.17	0.67	4	1	1	3	0	1
80	Mission Rd	Congress St	22nd St	1.1	64	146	1.04	0.63	0.75	1.66	2.42	3.33	5.76	0.73	9	3	0	0	7	0
81	Mission Rd	Ajo Way	Irvington Rd	1.3	66	151	0.96	0.51	0.62	1.87	2.31	2.56	4.87	0.90	6	1	11	1	6	0
82	Mission Rd	Irvington Rd	Drexel Rd	0.9	66	151	0.31	0.07	0.14	4.58	0.74	0.37	1.11	2.00	1	0	1	0	0	0
83	Oak Tree Drive	Midvale Park Rd	Valencia Rd	1.8	14	56	2.17	0.82	1.09	2.67	1.11	1.67	2.78	0.67	0	0	5	4	3	1
84	Midvale Park Rd	Irvington Rd	Drexel Rd	0.9	40	128	2.54	0.95	1.33	2.67	3.70	4.44	8.15	0.83	1	2	8	5	3	1
85	Midvale Park Rd	Drexel Rd	Valencia Rd	1.0	48	118	1.14	1.24	1.21	0.92	2.00	5.33	7.33	0.38	2	1	8	2	6	0
86	Valley Rd	Ajo Way	Irvington Rd	1.0	4	18	0.00	1.52	1.25	0.00	0.00	1.00	1.00	0.00	0	0	0	0	1	0
87	Calle Santa Cruz	Irvington Rd	Drexel Rd	1.0	9	28	3.04	1.30	1.73	2.33	1.00	1.33	2.33	0.75	1	2	2	1	1	0
88	Calle Santa Cruz	Drexel Rd	Valencia Rd	1.0	17	51	1.07	0.72	0.81	1.50	0.67	1.33	2.00	0.50	1	1	0	2	2	0
89	Romero Rd	Gardner Ln	Prince Rd	0.8	31	110	0.37	1.25	1.05	0.30	0.42	5.00	5.42	0.08	6	1	1	1	2	0
90	Fairview Ave	Roger Rd	Prince Rd	0.5	13	72	2.81	3.30	3.22	0.85	1.33	8.67	10.00	0.15	4	1	4	1	3	1
91	Fairview Ave	Prince Rd	Miracle Mile	0.7	18	61	0.72	1.50	1.32	0.48	0.48	3.33	3.81							

SEGMENT	ON STREET	FROM STREET	TO STREET	DISTANCE (MILES)	VOLUMES (x100)			Night Rate	Day Rate	Total Rate	Ratio NT / DY	Night Accident Freq	Day Accident Freq	Total Accident Freq	Ratio NT / DY	FIXED OBJECT ACC	NIGHT PED ACC	COLLISION MANEUVERS			
					NIGHT	DAY	ANGLE											LEFT TURN	REAR END	HEAD ON	
101	Park Ave	Grant Rd	Speedway Blvd	1.0	40	54	3.65	8.29	6.31	0.44	5.33	16.33	21.67	0.33	4	3	27	5	9	0	
102	Park Ave	Ajo Way	Irvington Rd	1.0	59	155	1.39	2.24	2.05	0.62	3.00	13.00	16.00	0.23	4	1	5	7	15	0	
103	Cherrybell Strav	22nd St	Silverlake Rd	0.5	22	80	2.49	0.46	0.90	5.45	2.00	1.33	3.33	1.50	0	0	1	2	1	0	
104	Campbell Ave	Winsett St	Aviation Pkwy	0.4	1	10	22.83	11.42	12.45	2.00	0.83	4.17	5.00	0.20	2	0	1	1	1	0	
105	Benson Hwy	Park Ave	Kino Pkwy	1.1	31	77	1.61	1.19	1.31	1.35	1.82	3.33	5.15	0.55	2	1	2	0	5	0	
106	Benson Hwy	Treat Ave	Country Club Rd	0.3	33	106	0.92	0.57	0.66	1.61	1.11	2.22	3.33	0.50	1	1	1	0	0	0	
107	Tucson Blvd	Prince Rd	Ft Lowell Rd	0.5	13	44	1.40	1.66	1.60	0.85	0.67	2.67	3.33	0.25	0	0	3	2	1	0	
108	Tucson Blvd	Ft Lowell Rd	Grant Rd	1.0	23	75	1.59	2.80	2.52	0.57	1.33	7.67	9.00	0.17	2	1	9	3	6	0	
109	Tucson Blvd	Grant Rd	Speedway Blvd	1.0	28	100	0.98	3.65	3.07	0.27	1.00	13.33	14.33	0.08	1	1	5	6	18	1	
110	Country Club Rd	Prince Rd	Ft Lowell Rd	0.5	63	152	2.03	2.28	2.21	0.89	4.67	12.67	17.33	0.37	0	1	3	2	18	0	
111	Country Club Rd	Glenn St	Grant Rd	0.5	59	144	3.41	5.71	5.04	0.60	7.33	30.00	37.33	0.24	3	2	7	9	39	2	
112	Country Club Rd	Grant Rd	Speedway Blvd	1.0	65	158	1.97	4.68	3.89	0.42	4.67	27.00	31.67	0.17	4	4	16	11	46	0	
113	Country Club Rd	Speedway Blvd	Broadway Blvd	1.0	64	165	2.85	4.82	4.27	0.59	6.67	29.00	35.67	0.23	7	3	6	13	68	0	
114	Country Club Rd	22nd St	Aviation Hwy	0.6	19	49	2.40	6.21	5.15	0.39	1.67	11.11	12.78	0.15	0	0	4	4	9	0	
115	Country Club Rd	36th St	Ajo Way	0.9	11	59	0.92	1.03	1.01	0.89	0.37	2.22	2.59	0.17	1	1	3	0	3	0	
116	Country Club Rd	Ajo Way	Irvington Rd	1.1	17	88	1.47	0.94	1.03	1.55	0.91	3.03	3.94	0.30	2	1	2	1	2	0	
117	Country Club Rd	Irvington Rd	Drexel Rd	1.1	16	78	0.52	0.85	0.79	0.61	0.30	2.42	2.73	0.13	0	0	3	1	2	0	
118	Country Club Rd	Drexel Rd	Valencia Rd	1.0	11	55	0.83	2.49	2.21	0.33	0.33	5.00	5.33	0.07	4	0	4	2	5	0	
119	Palo Verde Ave	Bilby Rd	Valencia Rd	0.5	41	118	0.45	0.62	0.57	0.72	0.67	2.67	3.33	0.25	0	0	1	2	1	0	
120	Alvernon Way	Kleindale	Ft Lowell Rd	0.7	3	20	8.70	0.65	1.70	13.33	0.95	0.48	1.43	2.00	2	1	1	0	1	0	
121	Alvernon Way	I-10	Valencia Rd	1.4	61	158	0.75	1.03	0.95	0.73	1.67	5.95	7.62	0.28	3	0	9	4	10	0	
122	Columbus Blvd	Grant Rd	Speedway Blvd	1.0	20	75	2.28	3.04	2.88	0.75	1.67	8.33	10.00	0.20	1	1	12	3	6	0	
123	Columbus Blvd	Speedway Blvd	5th St	0.5	18	86	4.06	1.91	2.28	2.12	2.67	6.00	8.67	0.44	0	0	2	2	6	1	
124	Columbus Blvd	Broadway Blvd	22nd St	1.0	15	71	1.83	1.80	1.81	1.01	1.00	4.67	5.67	0.21	3	1	5	2	4	0	
125	Columbus Blvd	22nd St	29th St	0.5	17	59	2.15	1.55	1.68	1.39	1.33	3.33	4.67	0.40	1	1	1	1	2	0	
126	Swan Rd	City Limits	Ft Lowell Rd	0.4	99	240	1.38	2.09	1.89	0.66	5.00	18.33	23.33	0.27	3	1	2	4	10	0	
127	Rosemont Blvd	Grant Rd	Speedway Blvd	1.0	9	63	4.06	2.61	2.79	1.56	1.33	6.00	7.33	0.22	2	0	9	1	7	0	
128	Rosemont Blvd	Speedway Blvd	Broadway Blvd	1.0	16	99	2.28	2.68	2.62	0.85	1.33	9.67	11.00	0.14	3	0	12	7	7	0	
129	Craycroft Road	City Limits	Grant Rd	1.2	71	198	0.96	1.96	1.70	0.49	2.50	14.17	16.67	0.18	1	3	10	12	26	0	
130	Wilmot Rd	Grant Rd	Pima St	0.5	16	78	2.28	2.11	2.14	1.08	1.33	6.00	7.33	0.22	1	0	2	2	4	0	
131	Calle Polar	Nicaragua Dr	Escalante Rd	0.3	19	76	1.60	0.80	0.96	2.00	1.11	2.22	3.33	0.50	1	1	0	0	0	1	
132	Sabino Canyon Rd	City Limits	Tanque Verde Rd	0.9	123	282	0.66	0.61	0.63	1.08	2.96	6.30	9.26	0.47	5	1	2	4	3	1	
133	Prudence Rd	22nd St	Golf Links Rd	1.0	10	42	1.83	1.52	1.58	1.20	0.67	2.33	3.00	0.29	6	2	1	2	0	0	
134	Prudence Rd	Golf Links Rd	Escalante Rd	1.0	6	37	3.04	0.99	1.27	3.08	0.67	1.33	2.00	0.50	0	0	0	1	2	0	
135	Sarnoff Dr	22nd St	Pantano Pkwy	0.5	8	36	2.28	0.51	0.83	4.50	0.67	0.67	1.33	1.00	1	2	0	1	2	0	
136	Camino Seco	Golf Links Rd	Escalante Rd	1.1	22	47	2.26	1.41	1.68	1.60	1.82	2.42	4.24	0.75	5	1	4	1	2	0	
137	Camino Seco	Escalante Rd	Irvington Rd	1.0	11	21	1.66	2.17	2.00	0.76	0.67	1.67	2.33	0.40	0	0	5	1	1	0	
138	Harrison Rd	Wrightstown Rd	Speedway Blvd	0.5	23	45	1.59	1.62	1.61	0.98	1.33	2.67	4.00	0.50	4	0	3	0	1	0	
139	Harrison Rd	Golf Links Rd	Escalante Rd	1.0	22	49	4.15	2.98	3.34	1.39	3.33	5.33	8.67	0.63	4	2	2	1	16	0	
140	Harrison Rd	Escalante Rd	Irvington Rd	1.0	22	49	0.42	1.12	0.90	0.37	0.33	2.00	2.33	0.17	2	1	0	1			

APPENDIX B

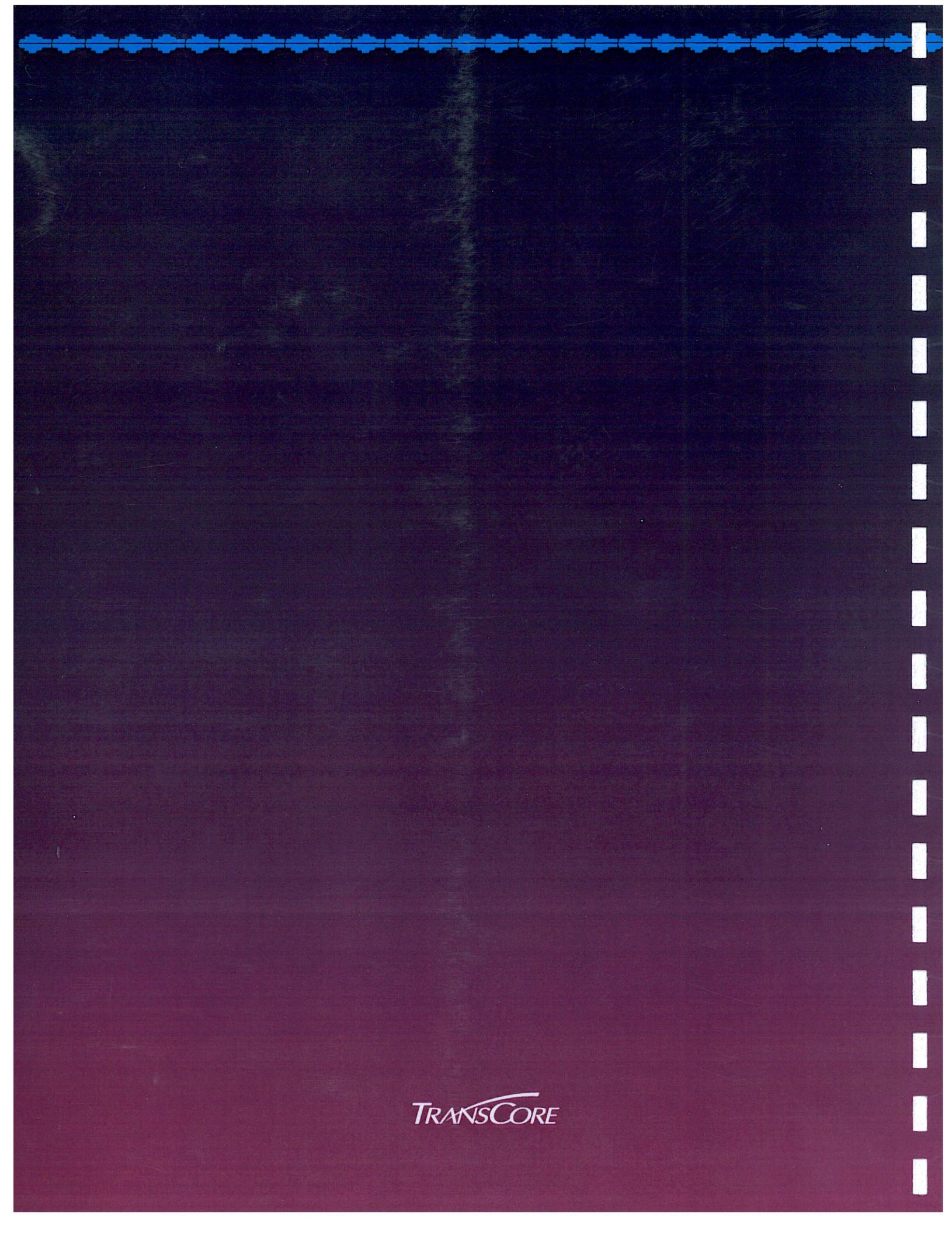
Priority Ranking Analysis All Segments

Seg	On Street	From Street	To Street	Length (miles)	Night ADT (100's)	Warranting Score	Street Class	Priority Score
69	W Valencia Road	City Limits	Oak Tree Dr	0.5	117	69.9	A	34.5
93	N 6th Avenue	Drachman St	Speedway Bld	0.2	26	79.1	A	23.3
95	E Toole Av	6th Ave	4th Ave	0.3	55	48.4	C	21.2
55	E Irvington Road	6th Ave	Park Ave	0.7	102	61.4	A	19.8
126	N Swan Road	City Limits	Fort Lowell	0.4	99	36.4	A	19.0
106	E Benson Highway	Treat Ave	Country Club Rd	0.3	33	67.4	A	17.7
132	N Sabino Canyon Road	City Limits	Tanque Verde Rd	0.9	123	58.2	A	16.8
110	N Country Club Road	Prince Rd	Fort Lowell Rd	0.5	63	54.3	A	15.5
56	E Irvington Road	Park Ave	Campbell Ave	0.7	103	46.7	A	15.2
24	Wrightstown Rd	Tanque Verde Rd	Wrightstown Terrace	0.6	33	108.0	A	15.0
80	S Mission Road	Congress St	22nd St	1.1	64	101.0	A	14.8
40	W 22nd Street	I-10	6th Ave	0.6	95	47.6	A	14.5
38	E Old Spanish Trail	Broadway Bld	Camino Seco	0.5	25	100.5	C	12.8
111	N Country Club Road	Glenn St	Grant Rd	0.5	59	47.4	A	12.6
6	W Wetmore Road	Fairview Ave	Oracle Rd	0.5	46	60.6	A	12.6
131	S Calle Polar	Nicaragua Dr	Escalante Rd	0.3	19	73.1	C	11.8
50	E Nicaragua Dr	Wilmot Rd	Calle Polar	0.3	21	65.4	C	11.7
2	E River Road	Oracle Rd	1st Ave	1.0	113	48.7	A	11.6
70	W Valencia Road	Oak Tree Dr	I-19	1.0	117	45.7	A	11.3
51	E Ajo Way	Benson Highway	Kino Pkwy	0.5	59	45.2	A	11.2
79	N Silverbell Road	St Marys Rd	Congress St	0.8	39	101.8	A	11.2
13	W Fort Lowell Road	Oracle Rd	1st Ave	1.0	100	50.4	A	11.2
82	S Mission Road	Irvington Rd	Drexel Rd	0.9	66	72.2	A	11.1
36	E Broadway Boulevard	Pantano Rd	Camino Seco	1.0	114	45.1	A	10.7
96	S 6th Avenue	Irvington Rd	Drexel Rd	1.0	46	86.6	C	10.2
4	E River Road	Dodge Bld	River Oak Tr	0.9	47	83.2	A	9.8
41	E 22nd Street	6th Ave	Kino Pkwy	1.1	108	51.8	A	9.8
37	E Broadway Boulevard	Camino Seco	Harrison Rd	1.0	72	51.1	A	9.2
15	E Fort Lowell Road	Campbell Ave	Country Club Rd	1.0	83	49.7	A	9.1
16	E Fort Lowell Road	Columbus Bld	Swan Rd	0.6	39	62.7	A	9.0
25	E Wrightstown Road	Tanque Verde Rd	Camino Seco Rd	0.8	32	89.0	A	9.0
14	E Fort Lowell Road	1st Ave	Campbell Ave	1.0	82	49.4	A	9.0
98	S Nogales Highway	6th Ave	Drexel Rd	1.0	43	80.8	A	8.5
42	E 22nd Street	Camino Seco	Harrison Rd	1.0	60	55.2	A	8.3
99	S Nogales Highway	Drexel Rd	Valencia Rd	1.0	43	77.4	A	8.1
119	S Palo Verde Avenue	Bilby Rd	Valencia Rd	0.5	41	44.6	A	8.1
84	S Midvale Park Road	Irvington Rd	Drexel Rd	0.9	40	76.0	A	8.1
23	E Tanque Verde Road	Tanque Verde Wash	Catalina Highway	1.2	107	37.4	A	8.0
34	E 5th Street	Swan Rd	Craycroft Rd	1.0	69	47.9	C	7.9
81	S Mission Road	Ajo Way	Irvington Rd	1.3	66	72.1	A	7.6
12	E Prince Road	Campbell Ave	Country Club Rd	1.0	57	59.0	A	7.6
60	W Drexel Road	Mission Rd	Santa Cruz River	1.1	38	88.0	C	7.3
113	N Country Club Road	Speedway Bld	Broadway Bld	1.0	64	48.8	A	7.1
32	E 5th Street	Country Club Rd	Alvernon Way	1.0	46	64.3	C	7.1
102	S Park Avenue	Ajo Way	Irvington Rd	1.0	59	48.4	A	7.0
68	E Valencia Road	City Limits	Wilmot Rd	0.9	73	35.8	A	6.9
112	N Country Club Road	Grant Rd	Speedway Bld	1.0	65	47.1	A	6.9
123	N Columbus Boulevard	Speedway Bld	5th St	0.5	18	79.2	C	6.8

Seg	On Street	From Street	To Street	Length (miles)	Night ADT (100's)	Warranting Score	Street Class	Priority Score
7	W Wetmore Road	Oracle Rd	1st Ave	1.0	62	47.8	A	6.6
125	S Columbus Boulevard	22nd St	29th St	0.5	17	80.9	C	6.6
5	W El Camino Del Cerro	Silverbell Rd	I-10	0.8	39	52.5	A	6.5
129	N Craycroft Road	City Limits	Grant Rd	1.2	71	48.5	A	6.4
52	E Escalante Road	Calle Polar	Kolb Rd	0.8	32	62.2	A	6.3
30	E Speedway Boulevard	Camino Seco	Harrison	1.0	47	51.8	A	6.1
75	N Silverbell Road	City Limits	El Camino Del Cerro	0.8	33	59.0	A	6.1
46	E 36th Street	Country Club Rd	City Limits	0.5	23	57.3	A	6.0
61	W Drexel Road	I-19	12th Ave	0.5	17	73.2	C	5.9
138	N Harrison Road	Wrightstown Rd	Speedway Bld	0.5	23	50.8	A	5.9
33	E 5th Street	Alvernon Way	Swan Rd	1.0	51	47.0	C	5.7
18	W Glenn Street	Oracle Rd	Stone Ave	0.4	19	49.3	C	5.6
19	E Glenn Street	Tucson Bld	Country Club Rd	0.5	18	64.3	C	5.5
101	N Park Avenue	Grant Rd	Speedway Bld	1.0	40	53.5	C	5.5
73	E Valencia Road	Old Vail Rd	Nexus Dr	0.9	42	46.3	A	5.5
29	E Pima Street	Alvernon Way	Swan Rd	1.0	44	50.6	C	5.3
76	N Silverbell Road	El Camino Del Cerro	Sweetwater	1.1	27	82.4	A	5.1
59	E Irvington Road	Camino Seco	Harrison Rd	1.0	24	79.4	A	4.8
17	W Glenn St	Flowing Wells Rd	Fairview Ave	0.4	10	80.2	C	4.8
62	E Drexel Road	12th Ave	Nogales Hwy	0.9	26	69.2	C	4.8
71	E Valencia Road	Country Club Rd	Alvernon Way	1.5	103	38.7	A	4.7
130	N Wilmot Road	Grant Rd	Pima St	0.5	16	58.5	C	4.5
57	E Irvington Road	Kolb Rd	Pantano Rd	1.0	31	56.8	A	4.4
78	N Silverbell Road	Goret Rd	Grant Rd	0.9	27	57.4	A	4.3
89	N Romero Road	Gardner Ln	Prince Rd	0.8	31	46.9	C	4.3
35	E 5th Street	Craycroft Rd	Wilmot Rd	1.0	38	46.3	C	4.2
136	S Camino Seco	Golf Links Rd	Escalante Rd	1.1	22	86.5	C	4.1
1	W River Rd	Thornydale Rd	Shannon Rd	1.3	57	44.4	A	4.1
9	W Roger Rd	Romero Rd	Flowing Wells Rd	0.6	22	46.7	C	4.1
139	S Harrison Road	Golf Links Rd	Escalante Rd	1.0	22	72.4	A	4.0
26	E Wrightstown Road	Camino Seco	Harrison	1.0	22	80.8	A	4.0
72	E Valencia Road	Kolb Rd	Old Vail Rd	2.3	42	86.3	A	4.0
47	E Stella Rd	Wilmot Rd	Calle Polar	0.3	11	42.3	C	4.0
135	S Sarnoff Drive	22nd St	Pantano Pkwy	0.5	8	103.1	C	3.9
85	S Midvale Park Rd	Drexel Rd	Valencia Rd	1.0	48	36.4	A	3.7
105	E Benson Highway	Park Ave	Kino Pkwy	1.1	31	61.9	A	3.7
114	S Country Club Road	22nd St	Aviation Hwy	0.6	19	51.3	A	3.7
58	E Irvington Road	Pantano Rd	Camino Seco	1.0	29	49.8	A	3.6
10	W Roger Road	Flowing Wells Rd	Oracle Rd	1.0	27	55.3	C	3.6
121	S Alvernon Way	I-10	Valencia	1.4	61	34.9	A	3.4
77	N Silverbell Road	Sweetwater Dr	Goret Rd	1.4	27	70.4	A	3.4
64	E Drexel Road	Campbell Ave	Country Club Rd	1.0	20	75.0	A	3.4
63	E Drexel Road	Nogales Hwy	Campbell Ave	1.1	31	48.2	C	3.2
107	N Tucson Boulevard	Prince Rd	Fort Lowell Rd	0.5	13	51.5	C	3.2
103	E Cherrybell Strav	22nd St	Silverlake Rd	0.5	11	54.7	C	3.1
94	N 6th Avenue	Speedway Bld	6th St	0.6	18	49.4	A	3.0
140	S Harrison Road	Escalante Rd	Irvington Rd	1.0	22	54.6	A	3.0
97	S 6th Avenue	Drexel Rd	Valencia Rd	1.0	15	78.4	C	3.0

Seg	On Street	From Street	To Street	Length (miles)	Night ADT (100's)	Warranting Score	Street Class	Priority Score
116	S Country Club Road	Ajo Way	Irvington Rd	1.1	17	75.9	A	3.0
39	E Old Spanish Trail	Camino Seco	Harrison Rd	1.2	19	72.8	C	2.9
11	E Roger Road	1st Ave	Campbell Ave	1.0	23	53.3	C	2.9
28	E Pima Street	Country Club Rd	Alvernon Way	1.0	24	50.1	C	2.9
21	E Glenn Street	Alvernon Way	Swan Rd	1.0	23	51.9	C	2.8
90	N Fairview Avenue	Roger Rd	Prince Rd	0.5	13	44.8	C	2.8
88	S Calle Santa Cruz	Drexel Rd	Valencia Rd	1.0	17	63.8	C	2.8
108	N Tucson Boulevard	Fort Lowell Rd	Grant Rd	1.0	23	49.7	C	2.7
91	N Fairview Avenue	Prince Rd	Miracle Mile	0.7	18	44.0	C	2.7
66	E Bilby Road	Nogales Hwy	Campbell Ave	1.1	16	71.2	C	2.5
43	E Silverlake Road	South Tucson	Cherrybell Strav	1.0	13	79.6	C	2.5
122	N Columbus Boulevard	Grant Rd	Speedway Bld	1.0	20	51.4	C	2.5
109	N Tucson Boulevard	Grant Rd	Speedway Bld	1.0	28	36.3	C	2.4
92	N Fairview Avenue	Miracle Mile	Grant Rd	0.8	15	50.2	C	2.2
124	S Columbus Boulevard	Broadway Bld	22nd St	1.0	15	58.2	C	2.1
65	W Bilby Road	12th Ave	Nogales Hwy	0.9	16	48.0	C	2.0
53	E Escalante Road	Pantano Rd	Camino Seco	1.0	17	46.8	A	2.0
45	E 36th Street	South Tucson	Campbell Ave	0.9	15	52.3	A	2.0
20	E Glenn Street	Country Club Rd	Alvernon Way	1.0	11	75.0	C	2.0
22	E Glenn Street	Swan Rd	Craycroft Rd	1.0	10	80.8	C	1.9
117	S Country Club Road	Irvington Rd	Drexel Rd	1.1	16	51.6	A	1.9
87	S Calle Santa Cruz	Irvington Rd	Drexel Rd	1.0	9	80.6	C	1.9
128	N Rosemont Boulevard	Speedway Bld	Broadway Bld	1.0	16	47.5	C	1.8
27	E Elm Street	Campbell Ave	Country Club Rd	1.0	9	82.8	C	1.8
115	S Country Club Road	36th St	Ajo Way	0.9	11	56.4	A	1.7
127	N Rosemont Boulevard	Grant Rd	Speedway Bld	1.0	9	69.2	C	1.5
83	S Oak Tree Drive	Midvale Park Rd	Valencia Rd	1.8	14	74.0	C	1.5
137	S Camino Seco	Escalante Rd	Irvington Rd	1.0	11	55.8	C	1.5
133	S Prudence Road	22nd St	Golf Links Rd	1.0	10	60.4	C	1.4
100	N Park Avenue	Fort Lowell Rd	Grant Rd	1.0	10	55.8	C	1.4
118	S Country Club Road	Drexel Rd	Valencia Rd	1.0	11	51.0	A	1.4
8	W Limberlost Drive	Oracle Rd	1st Ave	1.0	14	44.0	C	1.3
31	W University Boulevard	Main Ave	6th Ave	0.5	3	85.0	C	1.2
134	S Prudence Road	Golf Links Rd	Escalante Rd	1.0	6	82.8	C	1.2
74	E Valencia Road	Nexus Dr	Houghton Rd	1.4	14	42.6	A	1.1
48	E Stella Road	Kolb Rd	Pantano Rd	1.0	7	63.4	C	1.1
49	E Stella Road	Pantano Rd	Camino Seco	1.0	9	48.4	C	1.0
120	N Alvernon Way	Kleindale	Fort Lowell Rd	0.7	3	92.4	A	0.9
44	Fairland Strav	Cherrybell Strav	Country Club Dr	1.3	5	86.9	C	0.9
54	E Escalante Road	Camino Seco	Pantano Creek	0.6	2	69.2	A	0.6
86	S Valley Road	Ajo Way	Irvington Rd	1.0	4	54.0	C	0.6
67	E Bilby Road	Campbell Ave	Country Club Rd	1.0	4	41.8	C	0.4
104	S Campbell Av	Winsett St	Aviation Pkwy	0.4	1	51.0	C	0.3
141	Kolb Road	Irvington Rd	Valencia Rd	2.0	9	33.2	A	0.3
142	Prudence Road	Broadway Bld	22nd St	1.0	1.7	76.2	C	0.3
3*	E River Road	1st Ave	Campbell Ave	1.2	93		A	0.0

*County Project Under Construction



*TRANS*CORE